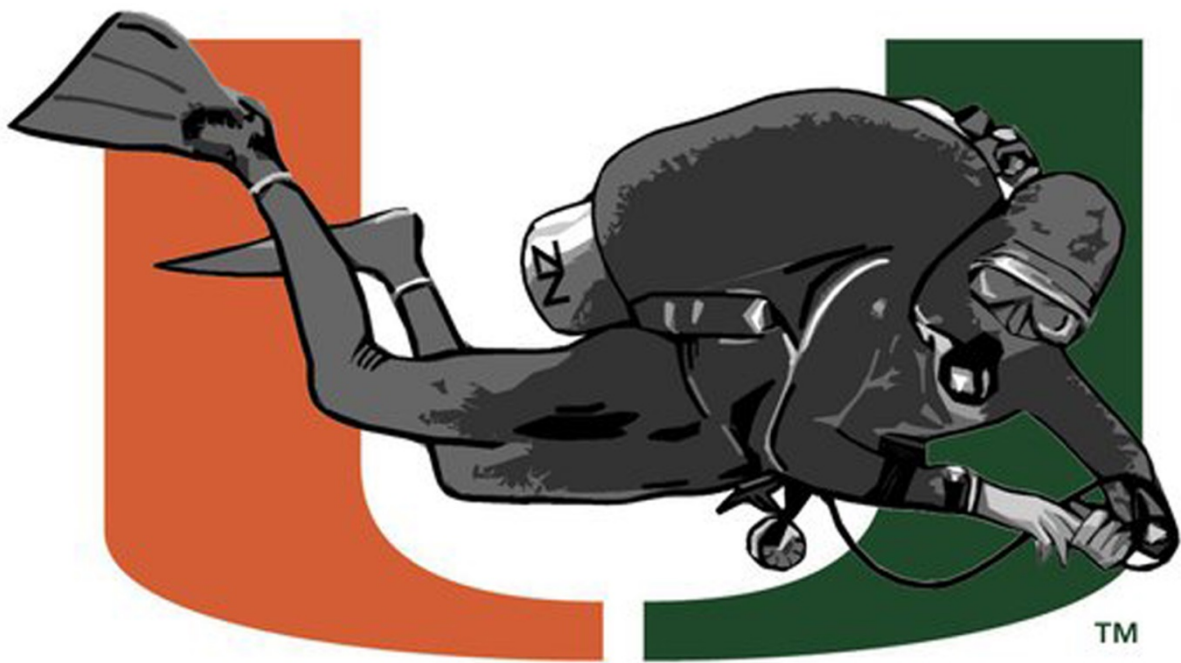


# University of Miami Diving Safety Manual



Revised January 2014

## FOREWORD

Since the 1930's University of Miami faculty, staff and students have ventured underwater in a quest to better understand it.

In 1951 the scientific diving community endeavored to promote safe, effective diving through self-imposed diver training and education programs. Over the years, manuals for diving safety have been circulated between organizations, revised and modified for local implementation, and have resulted in an enviable safety record.

This document represents the minimal safety standards for scientific diving at the present day. As diving science progresses so shall this standard and it is the responsibility of every member of the Academy to see that it always reflects state of the art, safe diving practice.

American Academy of Underwater Sciences

## ACKNOWLEDGEMENTS

The University of Miami and American Academy of Underwater Sciences thanks the numerous dedicated individual and organizational members for their contributions and editorial comments in the production of these standards.

### Revision History

April, 1987

October, 1990

May, 1994

January, 1996

March 1999 Added Sec 7.6.1 Nitrox Diving Guidelines.  
Revised Appendix 7 and 11.

January 2001 Revised Section 1.23.1 DSO Qualifications.  
Revised Section 5.31.4 Emergency Care Training. Revised Section 6 Medical Standards.  
Made Sec 7.6.1 Nitrox Diving Guidelines into Section 7. Added Section 8.0 Scientific Aquarium Diving.

Moved Section 7.0 to Section 9.0 Other Diving Technologies.  
April 2002 Removed Appendix 7 AAUS Checkout Dive and Training Evaluation.  
Revised Section 5.33.3. Revised Section 4.23.2.

August 2003 Section 1.27.3 Delete reference to Appendix 9 (checkout dive).

Section 1.4 Remove word "waiver".

Section 2.21 Change "supervisor" to "lead diver".

Section 2.72.2.1 Remove reference to Appendix 13, and remove Appendix 13. Replace with "at [www.aaus.org](http://www.aaus.org)" after Incident Report.

Section 3.28.3 Remove Appendix 10 (dive computers).

Section 5.32 Training and 100-hour requirement, eliminate "beyond the DIT level".

Section 5.32.1 Eliminate paragraph "Suggested topics include" and replace it with a list of topics for inclusion in the 100 hours. Some of these topics would be designated "R" (required). Section 4.0 Remove lead sentence "This section describes for diving". Alter the lead sentence read as follows: "This section describes training for the non-diver applicant, previously not certified for diving, and equivalency for the certified diver."

Section 4.3 Delete this section.

Section 9 Update Required Decompression (9.10) and Mixed Gas Diving (9.60) to individual sections.

Appendices 9, 10, 11, and 12 Remove these and make available online as historic documents in the Virtual Office.

Formatted document for consistency.

Separated manual into two volumes. Volume 1 and the appendices are required for all

manual and Volume 2 sections only apply when the referenced diving activity is being conducted. Volume 2 is where organizational specific information is contained.

- October 2005 Section 11.70 Deleted section for rebreathers.  
Section 12.00 Added new section for rebreathers.
- March 2006 Section 13.00 Added new section for cave and cavern diving.
- April 2006 Section 11.5 and 11.6, revised definitions for Hookah and surfaced supplied diving.  
Section 5.30 Deleted emergency care training prerequisite.  
Section 5.50 Added emergency care training requirements to Continuation of Certificate.
- November 2006  
Section 2.60 flying after diving rules updated to meet current DAN standards.  
Section 3.20 dive computers reference changed to “appendix 8”.  
Section 3.60 air quality guidelines updated to meet current CGA standards. Section 5.30 – added words “Transect Sampling “to item #9.  
Appendix 1 – Updated one medical web link.  
Appendix 2 - Added the abbreviation “DO” to the MD signature line. Appendix 6 – new LOR template.  
Updated and added Appendix 8 dive computer recommendations  
Added Appendix 9 (criteria for entering diving statistics).
- January 2014 Revision – Transition to AAUS manual format  
Consolidated Appendices  
Reformatted font and text

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## SECTION 1.00 GENERAL POLICY

### 1.10 Scientific Diving Standards

#### *Purpose*

The purpose of these policies and procedures is to ensure that all scientific diving conducted under the auspices of the University of Miami (UM) and UM Rosenstiel School of Marine of Atmospheric Sciences is performed in a manner that will maximize protection of UM scientific divers from accidental injury and/or illness, and to set forth standards for training and authorization that will allow a working reciprocity between American Academy of Underwater Sciences (AAUS) organizational members. Fulfillment of the purposes shall be consistent with the furtherance of research and safety.

These policies and procedures set minimal standards for diving under the auspices of UM/RSMAS. It also establishes a framework for reciprocity between AAUS organizational members that adhere to these minimum standards.

This standard was developed and written by AAUS and UM by compiling the policies set forth in the diving manuals of several university, private, and governmental scientific diving programs. These programs share a common heritage with the scientific diving program at the Scripps Institution of Oceanography (SIO). Adherence to the SIO standards has proven both feasible and effective in protecting the health and safety of scientific divers since 1954.

In 1982, OSHA exempted scientific diving from commercial diving regulations (29CFR1910, Subpart T) under certain conditions that are outlined below. The final guidelines for the exemption became effective in 1985 (Federal Register, Vol. 50, No.6, p.1046). AAUS is recognized by OSHA as the scientific diving standard setting organization.

#### *Scientific Diving Definition*

Scientific diving is defined (29CFR1910.402) as diving performed solely as a necessary part of a scientific, research, or educational activity by employees whose sole purpose for diving is to perform scientific research tasks.

#### *Scientific Diving Exemption*

OSHA has granted an exemption for scientific diving from commercial diving regulations under the following guidelines (Appendix B to 29CFR1910 Subpart T):

- a) The Diving Control Board consists of a majority of active scientific divers and has autonomous and absolute authority over the scientific diving program's operation.
- b) The purpose of the project using scientific diving is the advancement of science; therefore, information and data resulting from the project are non-proprietary.
- c) The tasks of a scientific diver are those of an observer and data gatherer. Construction and troubleshooting tasks traditionally associated with commercial diving are not included within scientific diving.
- d) Scientific divers, based on the nature of their activities, must use scientific expertise in studying the

underwater environment and therefore, are scientists or scientists-in-training.

- e) In addition, the scientific diving program shall contain at least the following elements (29CFR1910.401):
  - a. Diving Safety Manual (See Section 1.20)
  - b. Diving Control Board (See Section 1.20)

### *Review of Standards*

As part of UM's annual report, any recommendations for modifications of these standards shall be submitted to the AAUS for consideration.

## **1.20 Operational Control**

### *University of Miami Auspices Defined*

For the purposes of these standards the auspices of the UM includes any scientific diving operation in which UM is connected because of ownership of any equipment used, locations selected, or relationship with the individual(s) concerned. This includes all cases involving the operations of employees of UM or employees of auxiliary organizations, where such employees are acting within the scope of their employment, and the operations of other persons who are engaged in scientific diving for UM or are diving as members of an organization recognized by UM.

It is UM's responsibility to adhere to the AAUS Standards for Scientific Diving Authorization and Operation of Scientific Diving Programs. The administration of the diving program will reside with UM's Diving Control Board (DCB).

The regulations herein shall be observed at all locations where scientific diving is conducted.

### *University of Miami's Scientific Diving Standards and Safety Manual*

UM shall develop and maintain a scientific diving safety manual that provides for the development and implementation of policies and procedures that will enable UM to meet requirements of local environments and conditions as well as to comply with the AAUS scientific diving standards.

### *Diving Safety Officer*

The Diving Safety Officer (DSO) serves as a member of the Diving Control Board (DCB). This person should have broad technical and scientific expertise in research related diving.

#### *a) Qualifications*

1. Shall be appointed by the responsible administrative officer or designee, with the advice and counsel of the Diving Control Board.
2. Shall be trained as a scientific diver.
3. Shall be a full member as defined by AAUS.
4. Shall be an active underwater instructor from an internationally recognized certifying agency.

#### *b) Duties and Responsibilities*

1. Shall be responsible, through the DCB, to the responsible administrative officer or

designee, for the conduct of UM's scientific diving program. The routine operational authority of the program, including the conduct of training and authorization, approval of dive plans, maintenance of diving records, and ensuring compliance with these standards and all relevant regulations of UM, rests with the Diving Safety Officer.

2. May permit portions of this program to be carried out by a qualified delegate, although the Diving Safety Officer may not delegate responsibility for the safe conduct of the local diving program.
3. Shall be guided in the performance of the required duties by the advice of the DCB, but operational responsibility for the conduct of the local diving program will be retained by the Diving Safety Officer.
4. Shall suspend diving operations considered to be unsafe or unwise.

#### *Diving Control Board*

- a) The Diving Control Board (DCB) shall consist of a majority of active scientific divers.
- b) Voting members shall include the Diving Safety Officer, the responsible administrative officer, or designee, and should include other representatives of the diving program. A chairperson and a secretary may be chosen from the membership of the board according to local procedure.
- c) Has autonomous and absolute authority over the scientific diving program's operation.
- d) Shall take disciplinary action for unsafe practices.
- e) Shall act as the official representative of UM in matters concerning the scientific diving program.
- f) Shall act as a board of appeal to consider diver-related problems.
- g) Shall recommend the issue, reissue, or the revocation of diving authorizations.
- h) Shall recommend changes in policy and amendments to UM's diving safety manual and AAUS as the need arises.
- i) Shall establish and/or approve training programs through which the applicants for authorization can satisfy the requirements of the UM's diving safety manual.
- j) Shall establish and/or approve facilities for the inspection and maintenance of diving and associated equipment.
- k) Shall periodically review the Diving Safety Officer's performance and program.
- l) Shall sit as a board of investigation to inquire into the nature and cause of diving accidents or violations of UM's diving safety manual.

#### *The DCB through the UM DSO*

- a) Shall approve and monitor diving projects
- b) Shall review and revise the diving safety manual



- c) Shall assure compliance with the diving safety manual
- d) Shall assure adherence to the buddy system for SCUBA diving
- e) Shall suspend diving programs that are considered to be unsafe or unwise
- f) Shall establish criteria for equipment selection and use
- g) Shall recommend new equipment or techniques
- h) Shall authorize the depths to which a diver has been trained
- i) Shall ensure that UM's air station(s) meet air quality standards as described in Section 3.60

### *Instructional Personnel*

- a) *Qualifications*
  - a. All personnel involved in diving instruction under the auspices of UM shall be qualified for the type of instruction being given.
- b) *Selection*
  - a. Instructional personnel will be selected by the responsible administrative officer, or designee, who will solicit the advice of the DCB in conducting preliminary screening of applicants for instructional positions.

### *Lead Diver*

For each dive, one individual shall be designated as the Lead Diver who shall be at the dive location during the diving operation. The Lead Diver shall be responsible for:

- a) Coordination with other known activities in the vicinity that are likely to interfere with diving operations.
- b) Ensuring all dive team members possess current authorization and are qualified for the type of diving operation.
- c) Planning dives in accordance with Section 2.20
- d) Ensuring safety and emergency equipment is in working order and at the dive site.
- e) Briefing dive team members on:
  - a. Dive objectives.
  - b. Unusual hazards or environmental conditions likely to affect the safety of the diving operation.
  - c. Modifications to diving or emergency procedures necessitated by the specific diving operation.
  - d. Suspending diving operations if in their opinion conditions are not safe.
  - e. Reporting to the DSO any physical problems or adverse physiological effects including symptoms of pressure-related injuries.

### *Reciprocity and Visiting Scientific Diver*

- a) Two or more AAUS Organizational Members engaged jointly in diving activities, or engaged jointly in the use of diving resources, shall designate one of the participating Diving Control Boards to govern the joint dive project.
- b) A Scientific Diver from one Organizational Member shall apply for permission to dive under the auspices of another Organizational Member by submitting to the Diving Safety Officer of the host Organizational Member a document containing all the information described in Appendix 4, signed by the Diving Safety Officer or Chairperson of the home Diving Control Board.
- c) A visiting Scientific Diver may be asked to demonstrate their knowledge and skills for the planned dive.
- d) If a host Organizational Member denies a visiting Scientific Diver permission to dive, the host Diving Control Board shall notify the visiting Scientific Diver and their Diving Control Board with an explanation of all reasons for the denial.

### *Waiver of Requirements*

The UM DCB through the DSO may grant a waiver for specific requirements of training, examinations, depth authorization, and minimum activity to maintain authorization. The medical and insurance requirements cannot be waived.

### **1.30 Consequences of Violation of Regulations by Scientific Divers**

Failure to comply with the regulations of UM's diving safety manual may be cause for the restriction or revocation of the diver's scientific diving authorization by action of the UM DCB.

### **1.40 Consequences of Violation of Regulations by UM**

Failure to comply with the regulations of this standard may be cause for the revocation or restriction of UM's recognition by AAUS.

### **1.50 Record Maintenance**

The Diving Safety Officer or designee shall maintain permanent records for each Scientific Diver authorized. The file shall include evidence of authorization level, log sheets, results of current physical examination, reports of disciplinary actions by the UM DCB, and other pertinent information deemed necessary.

#### *Availability of Records:*

- a) Medical records shall be available to the attending physician of a diver or former diver when released in writing by the diver.
- b) Records and documents required by this standard shall be retained by UM for the following period:
  - 1. Physician's written reports of medical examinations for dive team members - 5 years.
  - 2. Diving safety manual - current document only.

3. Records of dive - 1 year, except 5 years where there has been an incident of pressure-related injury.
4. Pressure-related injury assessment - 5 years.
5. Equipment inspection and testing records - current entry or tag, or until equipment is withdrawn from service.

## **SECTION 2.00 DIVING REGULATIONS FOR SCUBA (OPEN CIRCUIT, COMPRESSED AIR)**

### **2.10 Introduction**

No person shall engage in scientific diving operations under the auspices of the UM unless they hold a current authorization issued pursuant to the provisions of this standard.

Failure to comply with the policies and procedures in the University of Miami/RSMAS Diving Safety Manual may be cause for the revocation or restriction of the diver's scientific diving authorization by action of the UM/RSMAS Diving Control Board.

### **2.20 Pre-Dive Procedures**

#### *Dive Plans*

Dives should be planned around the competency of the least experienced diver. Before conducting any diving operations under the auspices of UM, the lead diver for a proposed operation must formulate a dive plan that should include the following:

- a) Divers' qualifications and the type of certificate or authorization held by each diver.
- b) Emergency plan (Appendix 2) with the following information:
  1. Name, telephone number, and relationship of person to be contacted for each diver in the event of an emergency.
  2. Nearest operational decompression chamber.
  3. Nearest accessible hospital.
  4. Available means of transport.
- c) Approximate number of proposed dives.
- d) Location(s) of proposed dives.
- e) Estimated depth(s) and bottom time(s) anticipated.
- f) Decompression status and repetitive dive plans, if required.
- g) Proposed work, equipment, and boats to be employed.
- h) Any hazardous conditions anticipated.

The DSO must receive a dive plan for dives involving UM divers only at least 2 weeks prior to departure. For trips or cruises including non-UM divers, the DSO must receive a dive plan 1 month prior to departure. Dive plans for day trips to local sites shall be submitted at least 2 days prior to the trip. It is in the interest of the projects to submit dive plans as early as possible for operations employing techniques not normally associated with research diving (ex. using power tools, etc.) The DSO reviews the plan, and if it complies with safe diving practices as stated in this manual, he/she approves it. The DSO also approves a Lead Diver. One copy of the dive plan is maintained by the UM DSO and one is given to the Master of the research vessel if appropriate.

## *Dive Planning*

- a) Divers shall plan to use a gas supply appropriate for the dive to be conducted. This supply should be capable of providing enough gas to the diver and their buddy at the end of the dive, allowing for the pair to share gas and do a safe ascent from the maximum depth to the surface or to the next decompression gas.

## *Pre-dive Safety Checks*

- a) Diver's Responsibility:
  - a. No dive team member shall be permitted to dive for the duration of any known condition, which is likely to adversely affect the safety and health of the diver or other dive members.
  - b. It is the diver's responsibility and duty to refuse to dive if, in their judgment, conditions are unfavorable, or if they would be violating the precepts of their training, of this standard, or UM's diving safety manual.
  - c. Scientific divers shall conduct a functional check of their diving equipment in the presence of the diving buddy or tender.
  - d. No dive team member shall be required to be exposed to hyperbaric conditions against their will, except when necessary to prevent or treat a pressure-related injury.
- b) Equipment Evaluations
  - a. Divers shall ensure that their equipment is in proper working order and that the equipment is suitable for the type of diving operation.
  - b. Each diver shall have a buoyancy compensating device.
- c) Site Evaluation - Environmental conditions at the site will be evaluated.

## **2.30 Diving Procedures**

### *Solo Diving Prohibition*

No solo diving is allowed under the auspices of the University of Miami.

### *Refusal to Dive*

- a) The decision to dive is that of the diver. A diver may refuse to dive, without fear of penalty, whenever they feel it is unsafe for them to make the dive.
- b) Safety - The ultimate responsibility for safety rests with the individual diver. It is the diver's responsibility and duty to refuse to dive if, in their judgment, conditions are unsafe or unfavorable, or if they would be violating the precepts of their training or the regulations in this standard.

### *Termination of the Dive*

- a) It is the responsibility of the diver to terminate the dive, without fear of penalty, whenever they feel it is unsafe to continue the dive, unless it compromises the safety of another diver already in the water.
- b) The dive shall be terminated while there is still sufficient cylinder pressure to permit the diver to safely reach the surface from the maximum depth, including decompression time, or to safely reach

an additional air source at the decompression station. Divers shall surface with a minimum of 500 PSI in their cylinder.

### *Ascent Rate*

- a) A diver's ascent rate shall not exceed 30 feet per minute.

### *Emergencies and Deviations from Regulations*

Any diver may deviate from the requirements of this standard to the extent necessary to prevent or minimize a situation that is likely to cause death, serious physical harm, or major environmental damage. A written report of such actions must be submitted to the Diving Control Board explaining the circumstances and justifications.

## **2.40 Post-Dive Procedures**

### *Post-Dive Safety Checks*

After the completion of a dive, each diver shall immediately report any physical problems, symptoms of decompression sickness, or equipment malfunctions to the lead diver or DSO.

When diving outside the no-decompression limits, the divers should remain awake for at least 1 hour after diving, and in the company of a dive team member who is prepared to transport them to a decompression chamber if necessary.

Any malfunctioning equipment must be removed from service until it has been repaired.

## **2.50 Emergency Procedures**

Each UM project will develop emergency procedures that follow the standards of care of the community and must include procedures for emergency care, recompression and evacuation for each dive location (Appendix 2).

## **2.60 Flying After Diving or Ascending to Altitude (Over 1000 feet)**

Following a Single No-Decompression Dive 30 ft or shallower: Divers should have a minimum preflight surface interval of 12 hours.

Following Multiple Dives per Day or Multiple Days of Diving or dives deeper than 100 ft.: Divers should have a minimum preflight surface interval of 18 hours.

Following Dives Requiring Decompression Stops: Divers should have a minimum preflight surface interval of 24 hours.

Before ascending to Altitude above (1000 feet) by Land Transport: Divers should follow the appropriate guideline for preflight surface intervals unless the decompression procedure used has accounted for the increase in elevation.

## **2.70 Record Keeping Requirements**

## *Personal Diving Log*

UM divers shall log every dive made under the auspices of the UM's program, and are encouraged to log all other dives. Logs must be completed on the dive log website (<http://um.diveaus.com/>) in a timely manner and kept on file by the DSO. The diving log shall include at least the following:

- a) Name of diver, buddy, and Lead Diver.
- b) Date, time, and location.
- c) Diving modes used.
- d) General nature of diving activities.
- e) Approximate surface and underwater conditions.
- f) Maximum depths, bottom time, and surface interval time.
- g) Diving tables or computers used.
- h) Detailed report of any near or actual incidents.

## *Required Incident Reporting*

All diving incidents requiring recompression treatment, or resulting in moderate or serious injury, or death shall be reported to UM's Diving Control Board and AAUS. UM's regular procedures for incident reporting, including those required by AAUS, shall be followed. The report will specify the circumstances of the incident and the extent of any injuries or illnesses.

Additional information must meet the following reporting requirements:

- a) UM shall record and report occupational injuries and illnesses in accordance with requirements of the appropriate Labor Code section.
- b) If pressure-related injuries are suspected, or if symptoms are evident, the following additional information shall be recorded and retained by UM, with the record of the dive, for a period of 5 years:
  1. Complete the UM Accident Report form and procedures.
  2. Complete AAUS Incident Report at <http://www.aaus.org>.
  3. Written descriptive report to include:
    - i. Name, address, phone numbers of the principal parties involved.
    - ii. Summary of experience of divers involved.
    - iii. Location, description of dive site, and description of conditions that led up to incident.
    - iv. Description of symptoms, including depth and time of onset.
    - v. Description and results of treatment.
    - vi. Disposition of case.
    - vii. Recommendations to avoid repetition of incident.
- c) UM shall investigate and document any incident of pressure-related injury and prepare a report that

may be forwarded to AAUS during the annual reporting cycle. This report must first be reviewed and released by UM's Diving Control Board.



## SECTION 3.00 DIVING EQUIPMENT

### 3.10 General Policy

All equipment shall meet the standards as determined by the UM Diving Safety Manual and the DCB/DSO. Equipment that is subjected to extreme usage under adverse conditions should require more frequent testing and maintenance.

All equipment shall be regularly examined by the person using it.

Divers using equipment from the UM DSO are responsible for the equipment's well-being and will be billed for equipment that is returned damaged or is lost.

### 3.20 Equipment

#### *Regulators*

- a) Only those makes and models specifically approved by the UM DSO shall be used.
- b) SCUBA regulators shall be inspected and tested prior to first use and every 12 months thereafter or as recommended by the manufacturer.
- c) Regulators will consist of a primary second stage and a backup second stage regulator (or alternate air source/ redundant air supply).

#### *Breathing Masks and Helmets*

Breathing masks and helmets shall have:

- a) A non-return valve at the attachment point between helmet or mask and hose, which shall close readily and positively.
- b) An exhaust valve.
- c) A minimum ventilation rate capable of maintaining the diver at the depth to which they are diving.

#### *SCUBA Cylinders*

- a) SCUBA cylinders shall be designed, constructed, and maintained in accordance with the applicable provisions of the Unfired Pressure Vessel Safety Orders.
- b) SCUBA cylinders must be hydrostatically tested in accordance with DOT standards.
- c) SCUBA cylinders must have an internal and external inspection at intervals not to exceed 12 months.
- d) SCUBA cylinder valves shall be functionally tested at intervals not to exceed 12 months.
- e) SCUBA cylinder pressures shall not be allowed to drop below 500 PSI during diving operations.

#### *Backpacks*

Backpacks without integrated floatation devices and weight systems shall have a quick release device designed to permit jettisoning with a single motion from either hand.

### *Gauges*

Gauges shall be inspected and tested on a regular basis.

### *Floatation Devices*

- a) Each diver shall have a buoyancy compensation device (BCD).
- b) Personal flotation systems, buoyancy compensators, dry suits, or other variable volume buoyancy compensation devices shall be equipped with an exhaust valve.
- c) These devices shall be functionally inspected and tested at intervals not to exceed 12 months.

### *Timing Devices, Depth, and Pressure Gauges*

- a) Both members of the buddy team must have an underwater timing device, an approved depth indicator, and a submersible pressure gauge.

### *Dive Tables, Dive Computers*

- a) If not planning a dive with a dive computer, a set of diving tables approved by the Diving Control Board, must be available at the dive location for all dives deeper than 30ft.
- b) Dive computers (DC's) may be utilized in place of diving tables, and must be approved by the Diving Control Board. AAUS recommendations on dive computers are located in Section 12.
- c) Divers must be authorized to by the UM DSO to use a dive computer. To be authorized to use a DC, a diver must pass a written test the covers the AAUS guidelines for DC use and demonstrate to the DSO or their designee that the diver is familiar with it and understands the unit they are seeking authorization to use.
- d) Divers are only permitted to use DC's that they have been authorized by the UM DSO to use.

## **3.30 Auxiliary Equipment**

### *Hand held underwater power tools*

- a) Electrical tools, and equipment used underwater shall be specifically approved for this purpose.
- b) Electrical tools and equipment supplied with power from the surface shall be de-energized before being placed into or retrieved from the water
- c) Hand held power tools shall not be supplied with power from the dive location until requested by the diver. Divers needing to use these types of tools must be trained in their use and approved to use them by the DSO.

### **3.40 Support Equipment**

#### *First aid supplies*

- a) A first aid kit containing items appropriate for the dives being conducted is recommended on site.
- b) An approved Oxygen delivery system is strongly recommended on site for all diving operations when feasible with a supply amount suitable for treatment appropriate for the site. NOTE: Some remote areas may be difficult to get compressed gas (Oxygen) cylinders to. In circumstances where having Oxygen on site is not possible, dive profiles should be as conservative as possible and other DCS prevention steps taken.

#### *Diver's Flag*

A diver's flag shall be displayed prominently whenever diving is conducted under circumstances where required or where water traffic is probable.

#### *Compressor Systems – UM Owned*

The following will be considered in design and location of compressor systems:

- a) Low-pressure compressors used to supply air to the diver if equipped with a volume tank shall have a check valve on the inlet side, a relief valve, and a drain valve.
- b) Compressed air systems over 500 PSIG shall have slow-opening shut-off valves.
- c) All air compressor intakes shall be located away from areas containing exhaust or other contaminants.

### **3.50 Equipment Maintenance**

#### *Record Keeping*

Each equipment modification, repair, test, calibration, or maintenance service shall be logged, including the date and nature of work performed, serial number of the item, and the name of the person performing the work for the following equipment:

- a) Regulators
- b) Submersible pressure gauges
- c) Depth gauges
- d) SCUBA cylinders
- e) Cylinder valves
- f) Compressors
- g) Gas control panels

- h) Air storage cylinders
- i) Air filtration systems
- j) Analytical instruments
- k) Buoyancy control devices
- l) Dry suits

*Compressor Operation and Air Test Records*

- a) Compressor gas analysis shall be performed on the Dive Office-based compressor quarterly or after 100 hours of operation, whichever occurs first. Portable compressors shall be tested every 100 hours of use or prior to each deployment. The results of these tests shall be maintained on file in the Dive Office.
- b) A log shall be maintained showing operation, repair, overhaul, filter maintenance, and temperature adjustment for each compressor.

**3.60 Air Quality Standards**

Breathing air for SCUBA shall meet the following specifications as set forth by the Compressed Gas Association (CGA Pamphlet G-7.1).

<b>CGA Grade E</b>	
<b>Component</b>	<b>Maximum</b>
Oxygen	20 - 22%/v
Carbon Monoxide	10 PPM/v
Carbon Dioxide	1000 PPM/v
Condensed Hydrocarbons	5 mg/m <sup>3</sup>
Total Hydrocarbons as Methane	25 PPM/v
Water Vapor ppm	(2)
Objectionable Odors	None

For breathing air used in conjunction with self-contained breathing apparatus in extreme cold where moisture can condense and freeze, causing the breathing apparatus to malfunction, a dew point not to exceed -50°F (63 pm v/v) or 10 degrees lower than the coldest temperature expected in the area is required.

## **SECTION 4.00 ENTRY-LEVEL TRAINING REQUIREMENTS**

Entry-level diver training and certification from an internationally recognized diver training agency is a prerequisite to scientific diver training. In lieu of writing/promulgating AAUS specific standards for entry-level divers, AAUS references here, the standards for entry-level diver training as defined by the WRSTC and/or ISO.

### 4.20 References

“Minimum Course Content for Open Water Diver Certification: - World Recreational Scuba Training Council (WRSTC), [www.wrstc.com](http://www.wrstc.com).

“Safety related minimum requirements for the training of recreational scuba divers – Part 2: Level 2 – Autonomous diver”. ISO24801-2:2007 – International Organization for Standardization (ISO) - [www.iso.org](http://www.iso.org).

## **SECTION 5.00 SCIENTIFIC DIVER AUTHORIZATION**

### **5.10 Authorization Types**

All divers diving under the auspices of the University of Miami must be authorized to do so by the DSO/DCB, in accordance with the following regulations. The UM/DCB through the UM DSO may grant a waiver for specific requirements to maintain authorization. The diving physical exam and proof of insurance requirements cannot be waived.

#### *Scientific Diver Authorization*

This is a permit to dive, usable only while it is current, and for the purpose intended.

#### *Temporary Diver Authorization*

This authorization constitutes a waiver of the requirements of this section and is issued only following a demonstration of the required proficiency in diving as stated in section 4. It is valid only for a limited time, as determined by the DSO. This authorization is not to be construed as a mechanism to circumvent existing standards set forth in this manual.

Some requirements of this section may be waived by the Diving Safety Officer if the person in question has demonstrated proficiency in diving and can contribute measurably to a planned dive and has the proper insurance. Temporary authorizations shall be restricted to the planned diving operation and shall comply with all other policies, regulations, and standards of this standard, including medical requirements.

### **5.20 General Policy**

UM requires that no person shall engage in scientific diving unless that person is authorized by UM or an organizational member pursuant to the provisions of this standard. Only a person diving under the auspices of the University of Miami, that subscribes to the practices of UM, is eligible for a scientific diver authorization.

### **5.30 Requirements for Scientific Diver Authorization**

Submission of documents and participation in aptitude examinations does not automatically result in authorization. The applicant must convince the Diving Safety Officer that they are sufficiently skilled and proficient to be authorized. Any applicant who does not possess the necessary judgment, under diving conditions, for the safety of the diver and their partner, may be denied scientific diving privileges. Minimum documentation and examinations required are as follows:

#### *Prerequisites*

- a) Application - Application for Authorization shall be made to the Diving Safety Officer.
- b) Medical approval. Each applicant for diver authorization shall submit a statement from a licensed physician, based on an approved medical examination, attesting to the applicant's fitness for diving (Section 6.00 and Appendices 1 through 4).
- c) Scientific Diver-In-Training Authorization - This authorization signifies that a diver has

completed and been certified as at least an open water diver through an internationally recognized certifying agency or scientific diving program, and has the knowledge skills and equivalent experience to that gained by successful completion of training as specified in Section 4.00.

### *Theoretical Training/ Knowledge Development*

The scientific diver candidate must complete theoretical aspects and practical training for a minimum cumulative time of 100 hours. Theoretical aspects shall include principles and activities appropriate to the intended area of scientific study.

- a) Required Topics (include, but not limited to):
  - a. Diving Emergency Care Training
    - i. Cardiopulmonary Resuscitation (CPR)
    - ii. Standard or Basic First Aid
    - iii. Recognition of DCS and AGE
    - iv. Accident Management
    - v. Field Neurological Exam
    - vi. Oxygen Administration
  - b. Dive Rescue
  - c. Dive Physics
  - d. Dive Physiology
  - e. Dive Environments
  - f. Decompression Theory and its Application
  - g. Scientific Diving Regulations and History
    - i. Scientific Dive Planning
    - ii. Coordination with other Agencies
    - iii. Appropriate Governmental Regulations
  - h. Scientific Methodology
  - i. Data Gathering Techniques (Only Items specific to area of study are required)
    - i. Transect Sampling (Quadrating)
    - ii. Transecting
    - iii. Mapping
    - iv. Coring
    - v. Photography
    - vi. Tagging
    - vii. Collecting
    - viii. Animal Handling
    - ix. Archaeology
    - x. Common Biota
    - xi. Organism Identification
    - xii. Behavior
    - xiii. Ecology
    - xiv. Site Selection, Location, and Re-location
    - xv. Specialized Equipment for data gathering
  - j. HazMat Training
  - k. HP Cylinders
  - l. Chemical Hygiene, Laboratory Safety (Use Of Chemicals)

- b) Suggested Topics (include, but not limited to):
  - a. Specific Dive Modes (methods of gas delivery)
    - i. Open Circuit
    - ii. Hooka
    - iii. Surface Supplied diving
  - b. Small Boat Operation
  - c. Rebreathers
    - i. Closed
    - ii. Semi-closed
  - d. Specialized Breathing Gas
    - i. Nitrox
    - ii. Mixed Gas
  - e. Specialized Environments and Conditions
    - i. Blue Water Diving,
    - ii. Ice and Polar Diving (Cold Water Diving)
    - iii. Zero Visibility Diving
    - iv. Polluted Water Diving,
    - v. Saturation Diving
    - vi. Decompression Diving
    - vii. Overhead Environments
    - viii. Aquarium Diving
    - ix. Night Diving
    - x. Kelp Diving
    - xi. Strong Current Diving (Live-boating)
    - xii. Potential Entanglement
  - f. Specialized Diving Equipment
    - i. Full face mask
    - ii. Dry Suit
    - iii. Diver Propulsion Vehicles
    - iv. Communications

*Practical Training/ Skill Development – Confined Water Evaluation*

At the completion of training, the trainee must satisfy the Diving Safety Officer or their designee of their ability to perform all of the following, as a minimum, in a pool or in sheltered water (all underwater skills must be performed while neutrally buoyant):

- a) Enter water with full equipment
- b) Clear face mask
- c) Demonstrate air sharing, including both buddy breathing and the use of a backup regulator, as both donor and recipient
- d) Demonstrate ability to alternate between snorkel and SCUBA while kicking
- e) Demonstrate understanding of underwater signs and signals
- f) Demonstrate understanding of in-water mouth-to-mouth resuscitation



- g) Rescue and transport, as a diver, a passive simulated victim of an accident
- h) Demonstrate ability to remove and replace equipment while submerged
- i) Demonstrate watermanship ability, which is acceptable to the instructor

#### *Practical Training/ Skill Development – Open Water Evaluation*

The trainee must satisfy an instructor, approved by the DSO, of his/her ability to perform at least the following in open water (all underwater skills must be performed while neutrally buoyant):

- a) Surface dive to a depth of 10 feet in open water without scuba
- b) Demonstrate proficiency in air sharing as both donor and receiver
- c) Enter and leave open water or surf, or leave and board a diving vessel, while wearing scuba gear
- d) Kick on the surface 400 yards while wearing scuba gear, but not breathing from the scuba unit
- e) Demonstrate judgement adequate for safe diving
- f) Demonstrate, where appropriate, the ability to maneuver efficiently in the environment, at and below the surface
- g) Complete a simulated emergency swimming ascent
- h) Demonstrate clearing of mask and regulator while submerged
- i) Demonstrate ability to achieve and maintain neutral buoyancy while submerged
- j) Demonstrate techniques of self-rescue and buddy rescue
- k) Navigate underwater
- l) Plan and execute a dive

#### *Checkout Dive/ Additional Experience*

Practical training must include a checkout dive, with evaluation of skills listed in this section (Open Water Evaluation), with the DSO or their designee followed by at least 11 ocean or open water dives in a variety of dive sites and diving conditions for a cumulative bottom time of 6 hours. The dives following the checkout dive must be supervised by the DSO or an authorized UM Scientific Diver approved by the DSO that has experience in the type of diving planned.

#### *Examinations*

- a) Written examination: before completing training, the trainee must pass a written examination that demonstrates knowledge of at least the following:
  - a. Function, care, use, and maintenance of diving equipment
  - b. Physics and physiology of diving
  - c. Diving regulations and precautions
  - d. Near-shore currents and waves
  - e. Dangerous marine animals
  - f. Emergency procedures, including buoyant ascent and ascent by air sharing
  - g. Currently accepted decompression procedures
  - h. Demonstrate the proper use of dive tables
  - i. Underwater communications
  - j. Aspects of freshwater and altitude diving
  - k. Hazards of breath-hold diving and ascents
  - l. Planning and supervision of diving operations
  - m. Diving hazards
  - n. Cause, symptoms, treatment, and prevention of the following: near drowning, air embolism, carbon dioxide excess, squeezes, oxygen poisoning, nitrogen narcosis, exhaustion and panic, respiratory fatigue, motion sickness, decompression sickness, hypothermia, and hypoxia/anoxia.
- b) Equipment: the trainee will be subject to examination/review of:
  - a. Personal diving equipment
  - b. Task specific equipment

#### **5.40 Diver Permits**

AAUS requires that no person shall engage in scientific diving unless that person is authorized by an organizational member pursuant to the provisions of this standard. Only a person diving under the auspices of the organizational member that subscribes to the practices of AAUS is eligible to be an authorized scientific diver.

##### *Scientific Diver-In-Training Permit*

A scientific diver in training is a permit to dive only while it is current and for the purpose intended. This permit signifies that a diver has completed and been certified as at least an entry level diver through an internationally recognized certifying agency or scientific diving program, and has the knowledge, skills, and experience necessary to continue training as a scientific diver under supervision as approved by the DSO.

##### *Scientific Diver Authorization*

This permit signifies a diver has completed all requirements in Section 5.0 and is authorized by UM to engage in scientific diving without supervision, as approved by the DSO. Submission of documents and participation in aptitude examinations does not automatically result in authorization. The applicant must convince the DSO that they are sufficiently skilled and proficient to be authorized. This skill will be acknowledged by the signature of the DSO. Any applicant who does not possess the necessary judgement, under diving conditions, for the safety of the diver and their partner, may be denied organizational member scientific diving privileges.

#### **5.50 Depth Authorizations and Progression to Next Depth Level**

An authorized scientific diver diving under the auspices of the UM may progress to the next depth level after successfully completing the requirements for the next level. Under these circumstances the scientific diver may exceed their depth limit by one depth authorization. Dives shall be planned and executed under supervision of the DSO, their designee or a diver authorized to this depth or greater.

- a) Authorization to 30 Foot Depth (30 ft. Diver) - Initial permit level, approved upon the successful completion of training listed in Section 4.00 and 5.30 and having completed at least 50 total dives.
  - a. Authorization - 30 ft. I (30I Diver) – This authorization allows the diver to complete all the dives a 30 ft diver can except for acting as the lead diver. To qualify as a 30 ft. diver and lead dives, the diver must conduct 50 total dives.
- b) Authorization to 60 Foot Depth (60 ft. Diver) - A diver holding a 30 ft. qualification may be authorized to a depth of 60 ft. after successfully completing, under the supervision of divers qualified to this depth or greater, 12 working dives to depths between 31 and 60 ft. for a minimum total time of 4 hours and a tables test demonstrating table proficiency. It is recommended that 60 - 130ft. divers get training and UM authorization for Nitrox diving.
- c) Authorization to 100 Foot Depth (100 ft. Diver) - A diver holding a 60 ft. authorization may be authorized to a depth of 100 ft. after successfully completing 6 working dives to depths between 61 and 100 ft. with a diver authorized to that depth or greater; passing a written exam on deep diving theory, gas consumption rates, and dive planning; and completing two open water dives with the DSO. It is recommended that divers diving to 100 ft. or deeper get training and UM authorization for mixed gas diving.
- d) Authorization to 130 Foot Depth (130 ft. Diver) - A diver holding a 100 ft. authorization may be authorized to a depth of 130 ft. after successfully completing, 4 dives to depths between 101 and 130 ft. with a diver authorized to this depth or greater. It is recommended that divers diving to 100 ft. or deeper get training and UM authorization for mixed gas diving.
- e) Authorization to Depths greater than 130 ft. (130+ Diver) - A diver holding a 130 ft. authorization may be authorized to depths greater than 130 feet after successfully completing a training course in decompression theory and techniques, mixed gas theory and completing at least one dive with the UM DSO.

Diving on air is not permitted beyond a depth of 130 feet.

## **5.60 Continuation and Maintaining of Authorization**

### *Minimum Activity to Maintain Authorization*

During any 12-month period, each authorized scientific diver must log a minimum of 12 dives. At least one dive must be logged near the maximum depth of the diver's authorization during each 6-month period. Divers authorized to 130ft or deeper may satisfy these requirements with dives to 130 feet or over. Failure to meet these requirements may be cause for reduction, revocation or restriction of authorization.

### *Re-qualification of Depth Rating*

Once the initial authorization requirements of Section 5.30 are met, divers whose depth

authorization has lapsed due to lack of activity may be re-qualified by procedures adopted by the UM DCB which will include at minimum a checkout dive and verification of current paperwork.

### *Medical Examination*

All authorized scientific divers must pass a medical examination at the intervals specified in Section 6.10. After each major illness or injury, as described in Section 6.10, an authorized scientific diver shall receive clearance to return to diving from a physician before resuming diving activities.

### *Emergency Care Training*

The scientific diver candidate must provide proof of training and receive re-training at the specified frequencies for all of the following:

- a) Adult CPR (must be current), annual refresher training required
- b) Emergency Oxygen administration (must be current), annual refresher training required
- c) First aid for diving accidents (must be current), bi-annual retraining required

### *Maintenance of Authorization*

It is the diver's responsibility to maintain current authorization. To maintain UM Scientific Diver authorization a diver must do all of the following:

- a) Keep dive logs up to date
- b) Keep dive physical current
- c) Log a minimum of 12 science dives with at least one to the diver's max. authorization depth. Divers authorized to 150 ft. and greater may meet this requirement by conducting dives to 130 ft.
- d) Keep emergency care training requirements up to date
- e) Maintain dive accident insurance coverage. This is automatic in the case of workman's compensation for faculty and staff. Students must maintain health insurance that covers them for hyperbaric Oxygen therapy.
- f) Keep HazMat training current (every three years).
- g) If using personal equipment for UM diving, it is the diver's responsibility to follow the manufacturer's recommendation for equipment service and must keep all servicing up to date for all personal gear in use.

## **5.70 Revocation of Authorization**

A diving authorization may be revoked or restricted for cause by the Diving Safety Officer or the DCB. Violations of regulations set forth in this standard, or other governmental subdivisions not in conflict with this standard, may be considered cause. The Diving Safety Officer shall inform the diver in writing of the reason(s) for revocation. The diver will be given the opportunity to present their case in writing to the

DCB for reconsideration and/or re-authorization. All such written statements and requests, as identified in this section, are formal documents, which will become part of the diver's file.

### **5.80 Re-Authorization Procedure**

If a diver's authorization expires or is revoked, they may be re-authorized after completing the re-authorization procedure and any additional requirements the Diving Safety Officer or the DCB may impose. This may be completed one on one with the DSO or may be part of a scientific diver course. In the case of a restriction or revocation of scientific diver authorization, the scientific diver shall be given an opportunity to present their case to the DCB before conditions for re-authorization are stipulated. Upon completion of the re-authorization the diver will be authorized to the Research Diver 30 ft. or 60 ft. level, based on the DSO's evaluation and the diver's past experience and training.

### **5.90 Special Circumstances/Urgent Needs**

#### *Basic Diver Checkout Procedure*

In the event a student/staff/faculty member's need for diving authorization cannot wait for the next course, and at the discretion of the DSO, he/she may be permitted to complete the Basic Diver Checkout Procedure on a one-to-one basis with the Diving Safety Officer or his/her designee. Upon completing the Basic Diver Checkout Procedure as outlined below, he/she will be authorized to dive as a Diver-In- Training with special provisions to be set by the Diving Safety Officer. This individual will be required to enroll and pass the next available Research Diver Intermediate Course. They will be authorized to dive upon successful completion of all of the following:

- a) Proof of previous diver certification (certification cards)
- b) Proof of at least 4 open water dives (in a formal logbook)
- c) Proof of insurance for hyperbaric Oxygen therapy
- d) Passing the dive physical
- e) Passing the swimming test (for details see section 4.10)
- f) Passing CPR/Oxygen Administration course
- g) Passing a pool checkout dive demonstrating basic diving skills (the pool checkout is at the Diving Safety Officers discretion for details of skills see section 4.42 D), and passing an open water checkout dive demonstrating the following:
  - a. mask & regulator clearing
  - b. ditch/don equipment u/w
  - c. hovering in mid-water (buoyancy control)
  - d. proper entries and exits
  - e. proper BCD use
  - f. proper descent and ascent
  - g. out of air procedures buddy breathing, octopus, and rescue procedures

## *Experienced Diver Checkout Procedure*

Experienced certified divers with a minimum of 50 logged dives in varying conditions must, at minimum, pass the Experienced Diver Checkout Procedure to be authorized to dive. This can be done one-on-one with the Diving Safety Officer, his/her designee, or as part of a Research Diver course in progress. Divers that complete this procedure are not permitted to act as the Lead Diver for their first 12 scientific dives under the auspices of the UM. Upon completion the diver will be authorized to the Research Diver 30 ft or 60 ft level, based on the DSO's evaluation and the diver's past experience.

- a) Submit the following forms:
  - a. Dive physical signed by physician using UM/RSMAS form
  - b. Medical history
  - c. Resume form with copy of all certification cards
  - d. Log book with proof of at least 50 logged dives
  - e. Application signed by advisor (if applicable)
  - f. Insurance form (workman's compensation or DAN)
  - g. Statement of understanding
- b) Pass a written exam which includes sections on equipment, physiology, physics, dive accident management, dive planning, dive tables, navigation, first aid, environment, and UM/RSMAS policies. Passing score is 80%.
- c) Pass a swimming test:
  - a. 400 yd. swim in less than 12 minutes (first 200yd freestyle)
  - b. 25 yd. swim underwater on 1 breath (no push off)
  - c. 15 minute float and/or tread water
  - d. 400 yd. in mask, fins, snorkel in 8 minutes (bring your own mask, snorkel and fins)
  - e. free dive to 15 ft. & retrieve 5 lbs. weight
- d) Complete an open water check out dive (the DSO may require a pool checkout dive prior to any open water diving) demonstrating:
  - a. Mask & regulator clearing
  - b. Ditch/don equipment u/w
  - c. Hovering in mid-water (buoyancy control)
  - d. Proper entries and exits
  - e. Proper BCD use
  - f. Proper descent and ascent
  - g. Out of air procedures (buddy breathing, octopus, and rescue procedures)
  - h. Safe diving practices and exercising good judgment.
- e) Current CPR/DAM certification
- f) Complete a diver rescue training class
- g) Proof of insurance for hyperbaric Oxygen therapy
- h) Personal equipment inspection
- i) Complete 12 working dives with a current UM/RSMAS diver

## **SECTION 6.00 MEDICAL STANDARDS**

### **6.10 Medical Requirements**

#### *General*

- a) The organizational member shall determine that divers have passed a current diving physical examination and have been declared by the examining physician to be fit to engage in diving activities as may be limited or restricted in the medical evaluation report.
- b) All medical evaluations required by this standard shall be performed by, or under the direction of, a licensed physician of the applicant-diver's choice, preferably one trained in diving/undersea medicine.
- c) The diver should be free of any chronic disabling disease and be free of any conditions contained in the list of conditions for which restrictions from diving are generally recommended. (Appendix 4)

### **6.20 Frequency of Medical Evaluations**

#### *Medical evaluation shall be completed:*

- a) Before a diver may begin diving, unless an equivalent initial medical evaluation has been given within the preceding 5 years (3 years if over the age of 40, 2 years if over the age of 60), UM has obtained the results of that examination, and those results have been reviewed and found satisfactory by the UM DSO.
- b) Thereafter, at 5 year intervals up to age 40, every 3 years after the age of 40, and every 2 years after the age of 60.
- c) Clearance to return to diving must be obtained from a physician following any major injury or illness, or any condition requiring hospital care. If the injury or illness is pressure related, then the clearance to return to diving must come from a physician trained in diving medicine.

### **6.30 Information Provided Examining Physician**

UM shall provide a copy of the medical evaluation requirements of this standard to the examining physician. (Appendices 1, 2, and 3).

### **6.40 Content of Medical Evaluations**

Medical examinations conducted initially and at the intervals specified in this section shall consist of all of the following:

- a) Applicant agreement for release of medical information to the Diving Safety Officer and the DCB (Appendix 4)
- b) Medical history (Appendix 4)
- c) Diving physical examination (Required tests listed below and in Appendix 4)

## 6.50 Conditions Which May Disqualify Candidates From Diving (Adapted from Bove, 1998)

- a) Abnormalities of the tympanic membrane, such as perforation, presence of a monomeric membrane, or inability to auto inflate (equalize) the middle ears
- b) Vertigo including Meniere's Disease
- c) Stapedectomy or middle ear reconstructive surgery
- d) Recent ocular surgery
- e) Psychiatric disorders including claustrophobia, suicidal ideation, psychosis, anxiety states, untreated depression
- f) Substance abuse, including alcohol
- g) Episodic loss of consciousness
- h) History of seizure
- i) History of stroke or a fixed neurological deficit
- j) Recurring neurologic disorders, including transient ischemic attacks
- k) History of intracranial aneurysm, other vascular malformation or intracranial hemorrhage
- l) History of neurological decompression illness with residual deficit
- m) Head injury with sequelae
- n) Hematologic disorders including coagulopathies
- o) Evidence of coronary artery disease or high risk for coronary artery disease
- p) Atrial septal defects
- q) Significant valvular heart disease - isolated mitral valve prolapse is not disqualifying
- r) Significant cardiac rhythm or conduction abnormalities
- s) Implanted cardiac pacemakers and cardiac defibrillators (ICD)
- t) Inadequate exercise tolerance
- u) Severe hypertension
- v) History of spontaneous or traumatic pneumothorax
- w) Asthma



- x) Chronic pulmonary disease, including radiographic evidence of pulmonary blebs, bullae or cysts
- y) Diabetes mellitus
- z) Pregnancy

#### **6.60 Laboratory Requirements for Diving Medical Evaluation and Intervals**

- a) Initial examination under age 40:
  - a. Medical History
  - b. Complete Physical Exam, emphasis on neurological and otological components
  - c. Chest X-ray
  - d. Spirometry
  - e. Hematocrit or Hemoglobin
  - f. Urinalysis
  - g. Any further tests deemed necessary by the physician.
- b) Periodic re-examination under age 40 (every 5 years):
  - a. Medical History
  - b. Complete Physical Exam, emphasis on neurological and otological components
  - c. Hematocrit or Hemoglobin
  - d. Urinalysis
  - e. Any further tests deemed necessary by the physician
- c) Initial exam over age 40:
  - a. Medical History
  - b. Complete Physical Exam, emphasis on neurological and otological components
  - c. Assessment of coronary artery disease using Multiple-Risk-Factor Assessment<sup>1</sup> (age, lipid profile, blood pressure, diabetic screening, smoker)
  - d. Resting EKG
  - e. Chest X-ray
  - f. Spirometry
  - g. Urinalysis
  - h. Hematocrit or Hemoglobin
  - i. Any further tests deemed necessary by the physician
  - j. Exercise stress testing may be indicated based on risk factor assessment.<sup>2</sup>
- d) Periodic re-examination over age 40 (every 3 years); over age 60 (every 2 years):
  - a. Medical History
  - b. Complete Physical Exam, emphasis on neurological and otological components \*
  - c. Assessment of coronary artery disease using Multiple-Risk-Factor Assessment<sup>1</sup> (age, lipid profile, blood pressure, diabetic screening, smoker)
  - d. Resting EKG
  - e. Urinalysis
  - f. Hematocrit or Hemoglobin
  - g. Any further tests deemed necessary by the physician
  - h. Exercise stress testing may be indicated based on risk factor assessment.<sup>2</sup>

#### **6.70 Physician's Written Report**

After any medical examination relating to the individual's fitness to dive, the organizational member shall obtain a written report prepared by the examining physician, that shall contain the examining physician's opinion of the individual's fitness to dive, including any recommended restrictions or limitations. This will be reviewed by the DCB.

The organizational member shall make a copy of the physician's written report available to the individual.

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<sup>1</sup>“Assessment of Cardiovascular Risk by Use of Multiple-Risk-Factor Assessment Equations.” Grundy et. al. 1999. AHA/ACC Scientific Statement. <http://www.acc.org/clinical/consensus/risk/risk1999.pdf>

<sup>2</sup>Gibbons RJ, et al. ACC/AHA Guidelines for Exercise Testing. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). Journal of the American College of Cardiology. 30:260-311, 1997. <http://www.acc.org/clinical/guidelines/exercise/exercise.pdf>

## SECTION 7.00 NITROX DIVING GUIDELINES

The following guidelines address the use of Nitrox by scientific divers under the auspices of the University of Miami (UM). Nitrox is defined for these guidelines as breathing mixtures composed predominately of Nitrogen and Oxygen, most commonly produced by the addition of Oxygen or the removal of Nitrogen from air.

### 7.10 Prerequisites

#### *Eligibility*

Only an authorized UM Scientific Diver or Scientific Diver In Training (Sections 4.00 and 5.00) diving under the auspices of the UM is eligible for authorization to use Nitrox. After completion, review and acceptance of application materials, training and qualification, an applicant will be authorized to use Nitrox within their depth authorization, as specified in Section 5.40.

#### *Application and Documentation*

Application and documentation for authorization to use Nitrox should be made on forms specified by the Diving Control Board (DCB).

### 7.20 Requirements for Authorization to Use Nitrox

Submission of documents and participation in aptitude examinations does not automatically result in authorization to use Nitrox. The applicant must convince the DSO (and possibly members of the DCB) that they are sufficiently skilled and proficient. The signature of the DSO on the authorization form will acknowledge authorization. After completion of training and evaluation, authorization to use Nitrox may be denied to any diver who does not demonstrate to the satisfaction of the DSO or DCB the appropriate judgment or proficiency to ensure the safety of the diver and dive buddy.

Divers who have been trained in the use of Nitrox outside the UM must pass a written exam demonstrating their understanding of Nitrox diving. Passing grade is an 80% or higher.

Prior to authorization to use Nitrox, the following minimum requirements should be met:

#### *Training*

The diver must complete additional theoretical and practical training beyond the Scientific Diver In Training air Authorization level, to the satisfaction of the UM DSO and DCB (Section 7.30).

#### *Examinations*

Each diver should demonstrate proficiency in skills and theory in written, oral, and/or practical examinations covering all of the following:

- a) Written examinations covering the information presented in the classroom training session(s) (i.e., gas theory, Oxygen toxicity, partial pressure determination, etc.)
- b) Practical examinations covering the information presented in the practical training session(s) (i.e., gas analysis, documentation procedures, etc.)
- c) Open water checkout dives, to appropriate depths, to demonstrate the application of theoretical

and practical skills learned

### *Minimum Activity to Maintain Authorization*

The diver should log at least one Nitrox dive per year. Failure to meet the minimum activity level may be cause for restriction or revocation of Nitrox authorization.

### **7.30 Nitrox Training Guidelines**

Training in these guidelines should be in addition to training for Diver-In-Training authorization (Section 4.00). It may be included as part of training to satisfy the Scientific Diver training requirements (Section 5.30).

#### *Classroom Instruction*

- a) Topics should include, but are not limited to all of the following:
  - a. Review of previous training
  - b. Physical gas laws pertaining to Nitrox
  - c. Partial pressure calculations and limits
  - d. Equivalent air depth (EAD) concept and calculations
  - e. Oxygen physiology and Oxygen toxicity
  - f. Calculation of Oxygen exposure and maximum safe operating depth (MOD)
  - g. Determination of decompression schedules (both by EAD method using approved air dive tables, and using approved Nitrox dive tables)
  - h. Dive planning and emergency procedures
  - i. Mixing procedures and calculations
  - j. Gas analysis
  - k. Personnel requirements
  - l. Equipment marking and maintenance requirements
  - m. Dive station requirements.
  
- b) The UM DCB may choose to limit standard Nitrox diver training to procedures applicable to diving, and subsequently reserve training such as Nitrox production methods, Oxygen cleaning, and dive station topics to divers requiring specialized authorization in these areas.

#### *Practical Training*

The practical training portion will consist of a review of skills as stated for SCUBA (Section 4.00), with additional training including all of the following:

- a) Oxygen analysis of Nitrox mixtures.
  
- b) Determination of MOD, Oxygen partial pressure exposure, and Oxygen toxicity time limits, for various Nitrox mixtures at various depths.
  
- c) Determination of Nitrogen-based dive limits status by EAD method using air dive tables, and/or using Nitrox dive tables, as approved by the DCB/DSO.
  
- d) Nitrox dive computer use may be included, as approved by the DCB/DSO.

*Written Examination (based on classroom instruction and practical training)*

Before authorization, the trainee should successfully pass a written examination demonstrating knowledge of at least all of the following:

- a) Function, care, use, and maintenance of equipment cleaned for Nitrox use
- b) Physical and physiological considerations of Nitrox diving (ex.: O<sub>2</sub> and CO<sub>2</sub> toxicity)
- c) Diving regulations and procedures as related to Nitrox diving, either SCUBA or surface-supplied (depending on intended mode)
- d) Given the proper information, calculation of all of the following:
  - a. Equivalent air depth (EAD) for a given fO<sub>2</sub> and actual depth
  - b. pO<sub>2</sub> exposure for a given fO<sub>2</sub> and depth
  - c. Optimal Nitrox mixture for a given pO<sub>2</sub> exposure limit and planned depth
  - d. Maximum operational depth (MOD) for a given mix and pO<sub>2</sub> exposure limit
  - e. For Nitrox production purposes, percentages/PSI of Oxygen present in a given mixture, and PSI of each gas required to produce a fO<sub>2</sub> by partial pressure mixing
- e) Dive table and dive computer selection and usage
- f) Nitrox production methods and considerations
- g) Oxygen analysis
- h) Nitrox operational guidelines (Section 7.40), dive planning, and dive station components

*Open water Dives*

A minimum of two supervised open water dives using Nitrox is required for authorization. The mode used in the dives should correspond to the intended application (i.e., SCUBA or surface-supplied). If the MOD for the mix being used can be exceeded at the training site, direct in-water supervision is required.

*Surface-Supplied Training*

All training as applied to surface-supplied diving (practical, classroom, and open water) will follow UM's surface-supplied diving standards.

**7.40 Scientific Nitrox Diving Regulations**

*Dive Personnel Requirements*

- a) Nitrox Diver In Training - A Diver In Training, who has completed the requirements of Section 4.00 and the training and authorization sections of these guidelines, may be authorized by the DSO to use Nitrox under the direct supervision a Scientific Diver who also holds Nitrox authorization. Dive depths should be restricted to those specified in the diver's authorization.

- b) Scientific Diver - A Scientific Diver who has completed the requirements of Section 5.00 and the

training and authorization sections of these guidelines, may be authorized by the DSO to use Nitrox. Depth authorization to use Nitrox should be the same as those specified in the diver's authorization, as described in Section. 5.40.

- c) Lead Diver - On any dive during which Nitrox will be used by any team member, the Lead Diver should be authorized to use Nitrox, and hold appropriate authorizations required for the dive, as specified in this Manual. Lead Diver authorization for Nitrox dives by the DSO and/or DCB should occur as part of the dive plan approval process.

In addition to responsibilities listed in Section 1.20, the Lead Diver should:

- a. As part of the dive planning process, verify that all divers using Nitrox on a dive are properly qualified and authorized
  - b. As part of the pre-dive procedures, confirm with each diver the Nitrox mixture the diver is using, and establish dive team maximum depth and time limits, according to the shortest time limit or shallowest depth limit among the team members.
  - c. The Lead Diver should also reduce the maximum allowable pO<sub>2</sub> exposure limit for the dive team if on-site conditions so indicate (see Sec. 7.42.).
- d) Any diver receiving Nitrox training outside UM must take and pass a written exam demonstrating his/her understanding of Nitrox diving

### *Dive Parameters*

#### a) Oxygen Exposure Limits

- a. The inspired Oxygen partial pressure experienced at depth should not exceed 1.4 Atmospheres Absolute (ATA) for working dives and 1.6 ATA for decompression. It is recommended that all dives be planned using a 1.4 ATA pO<sub>2</sub> for the bottom portion of the dive. For decompression dives, it is recommended that a 1.2 ATA pO<sub>2</sub> be used. All dives performed using Nitrox breathing mixtures should comply with the current *NOAA Diving Manual* "Oxygen Partial Pressure Limits for 'Normal' Exposures."
- b. The maximum allowable exposure limit should be reduced in cases where cold or strenuous dive conditions, or extended exposure times are expected. The DCB should consider this in the review of any dive plan application, which proposes to use Nitrox. The Lead Diver should also review on-site conditions and reduce the allowable pO<sub>2</sub> exposure limits if conditions indicate.
- c. If using the equivalent air depth (EAD) method the maximum depth of a dive should be based on the Oxygen partial pressure for the specific Nitrox breathing mix to be used.

#### b) Bottom Time Limits

- a. Maximum bottom time should be based on the depth of the dive and the Nitrox mixture being used.
- b. Bottom time for a single dive should not exceed the NOAA maximum allowable "Single Exposure Limit" for a given Oxygen partial pressure, as listed in the current NOAA Diving Manual.

#### c) Dive Tables and Gases

- a. A set of DCB/DSO approved Nitrox dive tables should be available at the dive site.
- b. When using the equivalent air depth (EAD) method, dives should be conducted using air dive tables approved by the DCB/DSO.
- c. If Nitrox is used to increase the safety margin of air-based dive tables, the MOD and

Oxygen exposure and time limits for the Nitrox mixture being dived should not be exceeded

- d. Breathing mixtures used while performing in-water decompression, or for bail-out purposes, should contain the same or greater Oxygen content as that being used during the dive, within the confines of depth limitations and Oxygen partial pressure limits set forth in Section 7.40 Dive Parameters.

d) Nitrox Dive Computers

- a. Dive computers may be used to compute decompression status during Nitrox dives. Manufacturers' guidelines and operations instructions should be followed.
- b. Use of Nitrox dive computers should comply with dive computer guidelines included in this Manual and should comply with the AAUS Dive Computer Guidelines.
- c. Nitrox dive computer users should demonstrate a clear understanding of the display, operations, and manipulation of the unit being used for Nitrox diving prior to using the computer, to the satisfaction of the DSO or designee.
- d. If Nitrox is used to increase the safety margin of an air-based dive computer, the MOD and Oxygen exposure and time limits for the Nitrox mixture being dived should not be exceeded.
- e. Dive computers capable of pO<sub>2</sub> limit and fO<sub>2</sub> adjustment should be checked by the diver prior to the start of each dive to assure compatibility with the mix being used.

e) Repetitive Diving

- a. Repetitive dives using Nitrox mixtures should be performed in compliance with procedures required of the specific dive tables or computer(s) used.
- b. Residual Nitrogen time should be based on the EAD for the specific Nitrox mixture to be used on the repetitive dive, and not that of the previous dive.
- c. The total cumulative exposure (bottom time) to a partial pressure of Oxygen in a given 24 hour period should not exceed the current *NOAA Diving Manual* 24- hour Oxygen Partial Pressure Limits for "Normal" Exposures.
- d. When repetitive dives expose divers to different Oxygen partial pressures from dive to dive, divers should account for accumulated Oxygen exposure from previous dives when determining acceptable exposures for repetitive dives. Both acute (CNS) and chronic (pulmonary) Oxygen toxicity concerns should be addressed.

f) Oxygen Parameters

- a. Mixtures meeting the criteria outlined in Section 7.40 may be used for Nitrox diving operations, upon approval of the DCB.
- b. Oxygen used for mixing Nitrox-breathing gas should meet the purity levels for "Medical Grade" (U.S.P.) or "Aviator Grade" standards.
- c. In addition to the AAUS Air Purity Guidelines (Section 3.60), the following standard should be met for breathing air that is either:
  - i. Placed in contact with Oxygen concentrations greater than 40%.
  - ii. Used in Nitrox production by the partial pressure mixing method with gas mixtures containing greater than 40% Oxygen as the enriching agent.

Air Purity:	CGA Grade E (Section 3.60)
Condensed Hydrocarbons	5mg/m <sup>3</sup>
Hydrocarbon Contaminants	No greater than 0.1 mg/m <sup>3</sup>

g) Gas Mixing and Analysis for UM Scientific Divers

- a. Individuals responsible for producing and/or analyzing Nitrox mixtures should be

- knowledgeable and experienced in all aspects of the technique.
- b. Only those individuals approved by the DSO and/or DCB should be responsible for mixing Nitrox mixtures.
  - c. It is the responsibility of the DCB/DSO to approve the specific Nitrox production method used.
  - d. Analysis Verification by User
    - i. It is the responsibility of each diver to analyze prior to the dive the Oxygen content of his/her SCUBA cylinder and acknowledge in writing the following information for each cylinder:  $fO_2$ , MOD, date of analysis, and user's name.
    - ii. Individual dive log reporting forms should report  $fO_2$  of Nitrox used, if different than 21%.

## 7.50 Nitrox Diving Equipment

All of the designated equipment and stated requirements regarding SCUBA equipment required in this Manual should apply to Nitrox SCUBA operations. Additional minimal equipment necessary for Nitrox diving operations includes:

- a) Labeled SCUBA Cylinders
- b) Oxygen Analyzers

### *Oxygen Cleaning and Maintenance Requirements*

- a) Requirement for Oxygen Service
  - a. All equipment, which during the dive or cylinder filling process is exposed to concentrations greater than 40% Oxygen at pressures above 150 PSI, should be cleaned and maintained for Oxygen service.
  - b. Equipment used with Oxygen or mixtures containing over 40% by volume Oxygen shall be designed and maintained for Oxygen service. Oxygen systems over 125 PSIG shall have slow-opening shut-off valves. This should include the following equipment: SCUBA cylinders, cylinder valves, SCUBA and other regulators, cylinder pressure gauges, hoses, diver support equipment, compressors, and fill station components and plumbing.

### *SCUBA Cylinder Identification Marking*

SCUBA cylinders to be used with Nitrox mixtures should have the following identification documentation affixed to the cylinder:

- a. Cylinders should be marked "NITROX", or "EANx", or "Enriched Air".
- b. Nitrox identification color-coding should include a 4-inch wide green band around the cylinder, starting immediately below the shoulder curvature. If the cylinder is not yellow, the green band should be bordered above and below by a 1-inch yellow band.
- c. The alternate marking of a yellow cylinder by painting the cylinder crown green and printing the word "NITROX" parallel to the length of the cylinder in green print is acceptable.
- d. Other markings, which identify the cylinder as containing gas mixes other than air, may be used as the approval of the DCB/DSO.
- e. A contents label should be affixed, to include the current  $fO_2$ , date of analysis, and MOD.
- f. The cylinder should be labeled to indicate whether the cylinder is prepared for Oxygen or



Nitrox mixtures containing greater than 40% Oxygen.

### *Regulators*

Regulators to be used with Nitrox mixtures containing greater than 40% Oxygen should be cleaned and maintained for Oxygen service, and marked in an identifying manner.

### *Other Support Equipment*

- a. An Oxygen analyzer is required which is capable of determining the Oxygen content in the SCUBA cylinder. Two analyzers are recommended to reduce the likelihood of errors due to a faulty analyzer. The analyzer should be capable of reading a scale of 0 to 100% Oxygen, within 1% accuracy.
- b. All diver and support equipment should be suitable for the  $fO_2$  being used.

### *Compressor system*

- a. Compressor/filtration system must produce oil-free air.
- b. An oil-lubricated compressor placed in service for a Nitrox system should be checked for oil and hydrocarbon contamination at least quarterly.

### *Fill Station Components*

All components of a Nitrox fill station that will contact Nitrox mixtures containing greater than 40% Oxygen should be cleaned and maintained for Oxygen service. This includes cylinders, whips, gauges, valves, and connecting lines.

## SECTION 8.00 STAGED DECOMPRESSION DIVING

Decompression diving shall be defined as any diving during which the diver cannot perform a direct return to the surface without performing a mandatory decompression stop to allow the release of inert gas from the diver's body.

The following procedures shall be observed when conducting dives requiring planned decompression stops.

### 8.10 Minimum Experience and Training Requirements

- a) Prerequisites shall include all of the following:
  - a. Scientific Diver qualification according to Section 5.00.
  - b. Minimum of 100 logged dives.
  - c. Demonstration of the ability to safely plan and conduct dives deeper than 100 feet.
  - d. Nitrox Authorization according to AAUS Section 7.00 recommended.
- b) Training shall be appropriate for the conditions in which dive operations are to be conducted.
- c) Minimum training shall include all of the following:
  - a. A minimum of 6 hours of classroom training to ensure theoretical knowledge to include: physics and physiology of decompression; decompression planning and procedures; gas management; equipment configurations; decompression method, emergency procedures.
  - b. It is recommended that at least one training session be conducted in a pool or sheltered water setting, to cover equipment handling and familiarization, swimming and buoyancy control, to estimate gas consumption rates, and to practice emergency procedures.
  - c. At least 6 open-water training dives simulating/requiring decompression shall be conducted, emphasizing planning and execution of required decompression dives, and including practice of emergency procedures.
  - d. Progression to greater depths shall be by 4-dive increments at depth intervals as specified in Section 5.40.
  - e. No training dives requiring decompression shall be conducted until the diver has demonstrated acceptable skills under simulated conditions.
  - f. The diver must demonstrate proficiently in all of the following skills during dives simulating and requiring decompression:
    - i. Buoyancy control (hold position within 3 ft. of target depth)
    - ii. Proper trim (horizontal body position)
    - iii. Proper ascent rate
    - iv. Equipment manipulation
    - v. Stage/decompression bottle use as pertinent to planned diving operation
    - vi. Buddy skills
    - vii. Gas management
    - viii. Time management
    - ix. Task loading
    - x. Emergency skills
  - g. Divers shall demonstrate to the satisfaction of the DSO or the DSO's designee proficiency in planning and executing required decompression dives appropriate to the conditions in which diving operations are to be conducted.
  - h. Upon successful completion of training, the diver shall be authorized to conduct required decompression dives with DSO approval.

## 8.20 Minimum Equipment Requirements

- a) Valve and regulator systems for primary (bottom) gas supplies shall be configured in a redundant manner that allows continuous breathing gas delivery in the event of failure of any one component of the regulator/valve system.
- b) Cylinders must have adequate volume and be configured for the planned diving operations. Aluminum cylinders are recommended for open water wetsuit diving. Steel cylinders are only permitted for use in open water if a DCB/DSO approved redundant buoyancy system is used.
- c) Primary second stage shall be on a hose 7 ft. long and attached to a first stage that is placed on the right post of double cylinders. This first stage shall also have the inflator hose attached to it. The backup second stage shall be on a 24 in. hose and must have a necklace attached to be worn around the neck and is attached to a first stage that is attached to the left post of the double cylinders. This first stage shall have a submersible pressure gauge attached.
- d) Minimum dive equipment shall include all of the following:
  - a. Diver location devices adequate for the planned diving operations and environment.
  - b. Decompression Schedules
  - c. Dive Timing Device(s)
  - d. Depth gauge(s)
  - e. Buoyancy Control Device(s)
  - f. Regulators
- e) Additional equipment and redundancy in some components may be required at the discretion of the DCB or DSO.

## 8.30 Minimum Operational Requirements

- a) Approval of dive plans to conduct required decompression dives shall be on a case-by- case basis.
- b) The maximum  $pO_2$  to be used for planning the bottom portion of a required decompression dives is 1.4 Atmospheres Absolute (ATA). It is recommended that a  $pO_2$  of 1.2ATA be used during bottom exposure.
- c) Divers gas supplies shall be adequate to meet planned operational requirements and foreseeable emergency situations.
- d) Decompression dives may be planned using dive tables, dive computers, and/or PC software approved by the DSO/DCB.
- e) Breathing gases used while performing in-water decompression shall contain the same or greater Oxygen content as that used during the bottom phase of the dive.
- f) The dive team prior to each dive shall review emergency procedures appropriate for the planned dive.
- g) If breathing gas mixtures other than air are used for required decompression, their use shall be in accordance with those regulations set forth in the appropriate sections of this standard.

- h) The maximum depth for required decompression using air as the bottom gas shall be 130 feet.
- i) Use of additional Nitrox and/or high-Oxygen fraction decompression mixtures as travel and decompression gases to decrease decompression obligations is encouraged.
- j) Use of alternate inert gas mixtures to limit narcosis is encouraged for depths greater than 100 feet.
- k) If a period of more than 6 months has elapsed since the last mixed gas dive, a series of progressive workup dives to return the diver(s) to proficiency status prior to the start of project diving operations are recommended.
- l) Mission specific workup dives are recommended.

## SECTION 9.00 MIXED GAS DIVING

Mixed gas diving is defined as dives done while breathing gas mixes containing proportions greater than 1% by volume of an inert gas other than Nitrogen.

### 9.10 Minimum Experience and Training Requirements

- a) Prerequisites include all of the following:
  - a. Nitrox authorization (Section 7.00)
  - b. If the intended use entails required decompression stops, divers will be authorized in decompression diving (Section 8.00).
  - c. Divers shall demonstrate to the DCB's satisfaction skills, knowledge, and attitude appropriate for training in the safe use of mixed gases.
  
- b) Classroom training including all of the following:
  - a. Review of topics and issues previously outlined in Nitrox and required decompression diving training as pertinent to the planned operations.
  - b. The use of Helium or other inert gases, and the use of multiple decompression gases.
  - c. Equipment configurations
  - d. Mixed gas decompression planning
  - e. Gas management planning
  - f. Thermal considerations
  - g. END determination
  - h. Mission planning and logistics
  - i. Emergency procedures
  - j. Mixed gas production methods
  - k. Methods of gas handling and cylinder filling
  - l. Oxygen exposure management
  - m. Gas analysis
  - n. Mixed gas physics and physiology
  
- c) Practical training including all of the following:
  - a. Confined water session(s) in which divers demonstrate proficiency in required skills and techniques for proposed diving operations.
  - b. A minimum of 6 open water training dives.
  - c. At least one initial dive shall be in 130 feet or less to practice equipment handling and emergency procedures.
  - d. Subsequent dives will gradually increase in depth, with a majority of the training dives being conducted between 130 feet and the planned operational depth.
  - e. Planned operational depth for initial training dives shall not exceed 260 feet.
  - f. Diving operations beyond 260 feet requires additional training dives.

### 9.20 Equipment and Gas Quality Requirements

- a) Equipment requirements shall be developed and approved by the DCB, and met by divers, prior to engaging in mixed-gas diving. Equipment shall meet other pertinent requirements set forth elsewhere in this standard.
  
- b) The quality of inert gases used to produce breathing mixtures shall be of an acceptable grade for human consumption.

### **9.30 Minimum Operational Requirements**

- a) Approval of dive plan applications to conduct mixed gas dives shall be on a case-by-case basis.
- b) All applicable operational requirements for Nitrox and decompression diving shall be met.
- c) The maximum  $pO_2$  to be used for planning required decompression dives is 1.6. It is recommended that a  $pO_2$  of less than 1.6 be used during bottom exposure.
- d) Maximum planned Oxygen Toxicity Units (OTU) will be considered based on mission duration.
- e) Divers decompressing on high-Oxygen concentration mixtures shall closely monitor one another for signs of acute Oxygen toxicity.
- f) If a period of more than 6 months has elapsed since the last mixed gas dive, a series of progressive workup dives to return the diver(s) to proficiency status prior to the start of project diving operations are recommended.

## SECTION 10.0 REBREATHERS

This section defines specific considerations regarding all of the following issues for the use of rebreathers:

- a) Training and/or experience verification requirements for authorization
- b) Equipment requirements
- c) Operational requirements and additional safety protocols to be used

Application of this standard is in addition to pertinent requirements of all other sections of this manual.

For rebreather dives that also involve staged decompression and/or mixed gas diving, all requirements for each of the relevant diving modes shall be met. Diving Control Board (DCB) reserves the authority to review each application of all specialized diving modes, and include any further requirements deemed necessary beyond those listed here on a case-by-case basis.

No diver shall conduct planned operations using rebreathers without prior review and approval of the DCB.

In all cases, trainers shall be qualified for the type of instruction to be provided. Training shall be conducted by agencies or instructors approved by DSO and DCB.

### 10.10 Definitions and General Information

- a) Rebreathers are defined as any device that recycles some or all of the exhaled gas in the breathing loop and returns it to the diver. Rebreathers maintain levels of Oxygen and carbon dioxide that support life by metered injection of Oxygen and chemical removal of carbon dioxide. These characteristics fundamentally distinguish rebreathers from open-circuit life support systems, in that the breathing gas composition is dynamic rather than fixed.
  - a. Advantages of rebreathers may include increased gas utilization efficiencies that are often independent of depth, extended no-decompression bottom times and greater decompression efficiency, and reduction or elimination of exhaust bubbles that may disturb aquatic life or sensitive environments.
  - b. Disadvantages of rebreathers include high cost and, in some cases, a high degree of system complexity and reliance on instrumentation for gas composition control and monitoring, which may fail. The diver is more likely to experience hazardous levels of hypoxia, hyperoxia, or hypercapnia, due to user error or equipment malfunction, conditions which may lead to underwater blackout and drowning. Inadvertent flooding of the breathing loop and wetting of the carbon dioxide absorbent may expose the diver to ingestion of an alkaline slurry (“caustic cocktail”).
  - c. An increased level of discipline and attention to rebreather system status by the diver is required for safe operation, with a greater need for self-reliance. Rebreather system design and operation varies significantly between make and model. For these reasons when evaluating any dive plan incorporating rebreathers, risk-management emphasis should be placed on the individual qualifications of the diver on the specific rebreather make and model to be used, in addition to specific equipment requirements and associated operational protocols.

- b) Oxygen Rebreathers. Oxygen rebreathers recycle breathing gas, consisting of pure Oxygen, replenishing the Oxygen metabolized by the diver. Oxygen rebreathers are generally the least complicated design, but are normally limited to a maximum operation depth of 20fsw due to the risk of unsafe hyperoxic exposure.
- c) Semi-Closed Circuit Rebreathers. Semi-closed circuit rebreathers (SCR) recycle the majority of exhaled breathing gas, venting a portion into the water and replenishing it with a constant or variable amount of a single Oxygen-enriched gas mixture. Gas addition and venting is balanced against diver metabolism to maintain safe Oxygen levels by means which differ between SCR models, but the mechanism usually provides a semi- constant fraction of Oxygen (FO<sub>2</sub>) in the breathing loop at all depths, similar to open- circuit SCUBA.
- d) Closed-Circuit Mixed Gas Rebreathers. Closed-circuit mixed gas rebreathers (CCR) recycle all of the exhaled gas and replace metabolized Oxygen via an electronically controlled valve, governed by electronic Oxygen sensors. Manual Oxygen addition is available as a diver override, in case of electronic system failure. A separate inert gas source (diluent), usually containing primarily air, heliox, or trimix, is used to maintain Oxygen levels at safe levels when diving below 20fsw. CCR systems operate to maintain a constant Oxygen partial pressure (PPO<sub>2</sub>) during the dive, regardless of depth.

## 10.20 Prerequisites

Specific training requirements for use of each rebreather model shall be defined by DCB on a case-by-case basis. Training shall include factory-recommended requirements, but may exceed this to prepare for the type of mission intended (e.g., staged decompression or heliox/trimix CCR diving).

### *Training Prerequisites*

- a) Active scientific diver status, with depth qualification sufficient for the type, make, and model of rebreather, and planned application.
- b) Completion of a minimum of 50 open-water dives on SCUBA.
- c) For SCR or CCR, a minimum 100-fsw-depth qualification is generally recommended, to ensure the diver is sufficiently conversant with the complications of deeper diving. If the sole expected application for use of rebreathers is shallower than this, a lesser depth qualification may be allowed with the approval of the DCB.
- d) Training in use of Nitrox mixtures containing 25% to 40% Oxygen is required. Training in use of mixtures containing 40% to 100% Oxygen may be required, as needed for the planned application and rebreather system. Training may be provided as part of rebreather training.

### *Training*

Successful completion of the following training program qualifies the diver for rebreather diving using the system on which the diver was trained, in depths of 130fsw and shallower, for dives that do not require decompression stops, using Nitrogen/Oxygen breathing media.

- a) Satisfactory completion of a rebreather training program authorized or recommended by the manufacturer of the rebreather to be used, or other training approved by the DCB. Successful



completion of training does not in itself authorize the diver to use rebreathers. The diver must demonstrate to the DCB or its designee that the diver possesses the proper attitude, judgment, and discipline to safely conduct rebreather diving in the context of planned operations.

- b) Classroom training shall include all of the following:
- a. A review of those topics of diving physics and physiology, decompression management, and dive planning included in prior scientific diver, Nitrox, staged decompression and/or mixed gas training, as they pertain to the safe operation of the selected rebreather system and planned diving application.
  - b. In particular, causes, signs and symptoms, first aid, treatment and prevention of all of the following must be covered:
    - i. Hyperoxia (CNS and Pulmonary Oxygen Toxicity)
    - ii. Middle Ear Oxygen Absorption Syndrome (Oxygen ear)
    - iii. Hyperoxia-induced myopia
    - iv. Hypoxia
    - v. Hypercapnia
    - vi. Inert gas narcosis
    - vii. Decompression sickness
  - c. Rebreather-specific information required for the safe and effective operation of the system to be used, including all of the following:
    - i. System design and operation, including:
    - ii. Counterlung(s)
    - iii. CO<sub>2</sub> scrubber
    - iv. CO<sub>2</sub> absorbent material types, activity characteristics, storage, handling and disposal
    - v. Oxygen control system design, automatic and manual
    - vi. Diluent control system, automatic and manual (if any)
    - vii. Pre-dive set-up and testing
    - viii. Post-dive break-down and maintenance
    - ix. Oxygen exposure management
    - x. Decompression management and applicable decompression tracking methods
    - xi. Dive operations planning
    - xii. Problem recognition and management, including system failures leading to hypoxia, hyperoxia, hypercapnia, flooded loop, and caustic cocktail
    - xiii. Emergency protocols and bailout procedures

*Practical Training (with model of rebreather to be used)*

- a) A minimum number of hours of underwater time.

Type	Pool/Confined Water	O/W Training	O/W Supervised
Oxygen Rebreather	1 dive, 90 min	4 dives, 120 min.*	2 dives, 60 min
Semi-Closed Circuit	1 dive, 90-120 min	4 dives, 120 min.**	4 dives, 120 min
Closed-Circuit	1 dive, 90-120 min	8 dives, 380 min.***	4 dives, 240 min

\* Dives should not exceed 20 fsw.  
 \*\* First two dives should not exceed 60 fsw. Subsequent dives should be at progressively greater depths, with at least one dive in the 80 to 100 fsw range.  
 \*\*\* Total underwater time (pool and open water) of approximately 500 minutes. First two open water dives should not exceed 60 fsw. Subsequent dives should be at progressively greater depths, with at least 2 dives in the 100 to 130 fsw range.

- b) Amount of required in-water time should increase proportionally to the complexity of rebreather

system used.

- c) Training shall be in accordance with the manufacturer's recommendations.

### *Practical Evaluations*

Upon completion of practical training, the diver must demonstrate to the DCB or its designee proficiency in pre-dive, dive, and post-dive operational procedures for the particular model of rebreather to be used. Skills shall include, at a minimum, all of the following:

- a) Oxygen control system calibration and operation checks
- b) Carbon dioxide absorbent canister packing
- c) Supply gas cylinder analysis and pressure check
- d) Test of one-way valves
- e) System assembly and breathing loop leak testing
- f) Pre-dive breathing to test system operation
- g) In-water leak checks
- h) Buoyancy control during descent, bottom operations, and ascent
- i) System monitoring and control during descent, bottom operations, and ascent
- j) Proper interpretation and operation of system instrumentation (PO<sub>2</sub> displays, dive computers, gas supply pressure gauges, alarms, etc, as applicable)
- k) Unit removal and replacement on the surface.
- l) Bailout and emergency procedures for self and buddy, including:
  - a. System malfunction recognition and solution
  - b. Manual system control
  - c. Flooded breathing loop recovery (if possible)
  - d. Absorbent canister failure
  - e. Alternate bailout options
  - f. Symptom recognition and emergency procedures for hyperoxia, hypoxia, and hypercapnia
- m) Proper system maintenance, including:
  - a. Full breathing loop disassembly and cleaning (mouthpiece, check-valves, hoses, counterlung, absorbent canister, etc.)
  - b. Oxygen sensor replacement (for SCR and CCR)
  - c. Other tasks required by specific rebreather models

### *Written Evaluation*

A written evaluation approved by the DCB with a pre-determined passing score, covering concepts of both classroom and practical training, is required.

*Supervised Rebreather Dives*

Upon successful completion of open water training dives, the diver is authorized to conduct a series of supervised rebreather dives, during which the diver gains additional experience and proficiency.

- a) Supervisor for these dives should be the DSO or designee, and should be an active scientific diver experienced in diving with the make/model of rebreather being used.
- b) Dives at this level may be targeted to activities associated with the planned science diving application. See the following table for number and cumulative water time for different rebreather types.

Type	Pool/Confined Water	O/W Training	O/W Supervised
Oxygen Rebreather	1 dive, 90 min	4 dives, 120 min.*	2 dives, 60 min
Semi-Closed Circuit	1 dive, 90-120 min	4 dives, 120 min.**	4 dives, 120 min
Closed-Circuit	1 dive, 90-120 min	8 dives, 380 min.***	4 dives, 240 min

\* Dives should not exceed 20 fsw.  
 \*\* First two dives should not exceed 60 fsw. Subsequent dives should be at progressively greater depths, with at least dive in the 80 to 100 fsw range.  
 \*\*\* Total underwater time (pool and open water) of approximately 500 minutes. First two open water dives should not exceed 60 fsw. Subsequent dives should be at progressively greater depths, with at least 2 dives in the 100 to 130 fsw range.

- c) Maximum ratio of divers per designated dive supervisor is 4:1. The supervisor may dive as part of the planned operations.

Extended Range, Required Decompression and Helium-Based Inert Gas Rebreather dives involving operational depths in excess of 130 fsw, requiring staged decompression, or using diluents containing inert gases other than Nitrogen are subject to additional training requirements, as determined by DCB on a case-by-case basis. Prior experience with required decompression and mixed gas diving using open-circuit SCUBA is desirable, but is not sufficient for transfer to dives using rebreathers without additional training.

- a) As a prerequisite for training in staged decompression using rebreathers, the diver shall have logged a minimum of 25 hours of underwater time on the rebreather system to be used, with at least 10 rebreather dives in the 100 fsw to 130 fsw range.
- b) As a prerequisite for training for use of rebreathers with gas mixtures containing inert gas other than Nitrogen, the diver shall have logged a minimum of 50 hours of underwater time on the rebreather system to be used and shall have completed training in stage decompression methods using rebreathers. The diver shall have completed at least 12 dives requiring staged decompression on the rebreather model to be used, with at least 4 dives near 130 fsw.
- c) Training shall be in accordance with standards for required-decompression and mixed gas diving, as applicable to rebreather systems, starting at the 130 fsw level.

*Maintenance of Proficiency*

- a) To maintain authorization to dive with rebreathers, an authorized diver shall make at least one dive

using a rebreather every 8 weeks. For divers authorized for the conduct of extended range, stage decompression or mixed-gas diving, at least one dive per month should be made to a depth near 130 fsw, practicing decompression protocols.

- b) For a diver in arrears, the DCB shall approve a program of remedial knowledge and skill tune-up training and a course of dives required to return the diver to full authorization. The extent of this program should be directly related to the complexity of the planned rebreather diving operations.

### **10.30 Equipment Requirements**

#### *General Requirements*

- a) Only those models of rebreathers specifically approved by DCB shall be used.
- b) Rebreathers should be manufactured according to acceptable Quality Control/Quality Assurance protocols, as evidenced by compliance with the essential elements of ISO 9004. Manufacturers should be able to provide to the DCB supporting documentation to this effect.
- c) Unit performance specifications should be within acceptable levels as defined by standards of a recognized authority (CE, US Navy, Royal Navy, NOAA, etc...).
- d) Prior to approval, the manufacturer should supply the DCB with supporting documentation detailing the methods of specification determination by a recognized third-party testing agency, including unmanned and manned testing. Test data should be from a recognized, independent test facility.
- e) The following documentation for each rebreather model to be used should be available as a set of manufacturer's specifications. These should include:
  - a. Operational depth range
  - b. Operational temperature range
  - c. Breathing gas mixtures that may be used
  - d. Maximum exercise level which can be supported as a function of breathing gas and depth
  - e. Breathing gas supply durations as a function of exercise level and depth
  - f. CO<sub>2</sub> absorbent durations, as a function of depth, exercise level, breathing gas, and water temperature
  - g. Method, range and precision of inspired PPO<sub>2</sub> control, as a function of depth, exercise level, breathing gas, and temperature
  - h. Likely failure modes and backup or redundant systems designed to protect the diver if such failures occur
  - i. Accuracy and precision of all readouts and sensors
  - j. Battery duration as a function of depth and temperature
  - k. Mean time between failures of each subsystem and method of determination
- f) A complete instruction manual is required, fully describing the operation of all rebreather components and subsystems as well as maintenance procedures.
- g) A maintenance log is required. The unit maintenance shall be up-to-date based upon manufacturer's recommendations.

#### *Minimum Equipment*

- a) A surface/dive valve in the mouthpiece assembly, allowing sealing of the breathing loop from the external environment when not in use.
- b) An automatic gas addition valve, so that manual volumetric compensation during descent is unnecessary.
- c) Manual gas addition valves, so that manual volumetric compensation during descent and manual Oxygen addition at all times during the dive are possible.
- d) The diver shall carry alternate life support capability (open-circuit bail-out or redundant rebreather) sufficient to allow the solution of minor problems and allow reliable access to a pre-planned alternate life support system.

### *Oxygen Rebreathers*

Oxygen rebreathers shall be equipped with manual and automatic gas addition valves.

### *Semi-Closed Circuit Rebreathers (SCR's)*

SCR's shall be equipped with at least one manufacturer-approved Oxygen sensor sufficient to warn the diver of impending hypoxia. Sensor redundancy is desirable, but not required.

### *Closed Circuit Mixed-gas Rebreathers (CCR's)*

- a) CCR shall incorporate a minimum of three independent Oxygen sensors.
- b) A minimum of two independent displays of Oxygen sensor readings shall be available to the diver.
- c) Two independent power supplies in the rebreather design are desirable. If only one is present, a secondary system to monitor Oxygen levels without power from the primary battery must be incorporated.
- d) CCR shall be equipped with manual diluent and Oxygen addition valves, to enable the diver to maintain safe Oxygen levels in the event of failure of the primary power supply or automatic gas addition systems.
- e) Redundancies in onboard electronics, power supplies, and life support systems are highly desirable.

## **10.40 Operational Requirements**

### *General Requirements*

- a) All dives involving rebreathers must comply with applicable operational requirements for open-circuit SCUBA dives to equivalent depths.
- b) No rebreather system should be used in situations beyond the manufacturer's stated design limits (dive depth, duration, water temperature, etc).
- c) Modifications to rebreather systems shall be in compliance with manufacturer's recommendations.

- d) Rebreather maintenance is to be in compliance with manufacturer's recommendations including sanitizing, replacement of consumables (sensors, CO<sub>2</sub> absorbent, gas, batteries, etc) and periodic maintenance.
- e) In addition to standard dive plan components stipulated in AAUS Section 2.0, all dive plans that include the use of rebreathers must include, at minimum, the following details:
  - a. Information about the specific rebreather model to be used
  - b. Make, model, and type of rebreather system
  - c. Type of CO<sub>2</sub> absorbent material
  - d. Composition and volume(s) of supply gases
  - e. Complete description of alternate bailout procedures to be employed, including manual rebreather operation and open-circuit procedures
  - f. Other specific details as requested by DCB

#### *Buddy Qualifications.*

- a) A diver whose buddy is diving with a rebreather shall be trained in basic rebreather operation, hazard identification, and assist/rescue procedures for a rebreather diver.
- b) If the buddy of a rebreather diver is using open-circuit SCUBA, the rebreather diver must be equipped with a means to provide the open-circuit SCUBA diver with a sufficient supply of open-circuit breathing gas to allow both divers to return safely to the surface.

#### *Oxygen Exposures*

- a) Planned Oxygen partial pressure in the breathing gas shall not exceed 1.4 atmospheres at depths greater than 30 feet.
- b) Planned Oxygen partial pressure set point for CCR shall not exceed 1.4 atm. Set point at depth should be reduced to manage Oxygen toxicity according to the NOAA Oxygen Exposure Limits.
- c) Oxygen exposures should not exceed the NOAA Oxygen single and daily exposure limits.
- d) Both CNS and pulmonary (whole-body) Oxygen exposure indices should be tracked for each diver.

#### *Decompression Management*

- a) DCB shall review and approve the method of decompression management selected for a given diving application and project.
- b) Decompression management can be safely achieved by a variety of methods, depending on the type and model of rebreather to be used. Following is a general list of methods for different rebreather types:
  - a. Oxygen rebreathers: Not applicable.
  - b. SCR (presumed constant FO<sub>2</sub>):
    - i. Use of any method approved for open-circuit SCUBA diving breathing air, above the maximum operational depth of the supply gas.
    - ii. Use of open-circuit Nitrox dive tables based upon expected inspired FO<sub>2</sub>. In this case, contingency air dive tables may be necessary for active-addition SCR's in the

- event that exertion level is higher than expected.
- iii. Equivalent air depth correction to open-circuit air dive tables, based upon expected inspired  $FO_2$  for planned exertion level, gas supply rate, and gas composition. In this case, contingency air dive tables may be necessary for active-addition SCR's in the event that exertion level is higher than expected.
- c. CCR (constant  $PPO_2$ ):
  - i. Integrated constant  $PPO_2$  dive computer.
  - ii. Non-integrated constant  $PPO_2$  dive computer.
  - iii. Constant  $PPO_2$  dive tables.
  - iv. Open-circuit (constant  $FO_2$ ) Nitrox dive computer, set to inspired  $FO_2$  predicted using  $PPO_2$  set point at the maximum planned dive depth.
  - v. Equivalent air depth (EAD) correction to standard open-circuit air dive tables, based on the inspired  $FO_2$  predicted using the  $PPO_2$  set point at the maximum planned dive depth.
  - vi. Air dive computer, or air dive tables used above the maximum operating depth (MOD) of air for the  $PPO_2$  setpoint selected.

#### *Maintenance Logs, CO<sub>2</sub> Scrubber Logs, Battery Logs, and Pre-And Post-Dive Checklists*

Logs and checklists will be developed for the rebreather used, and will be used before and after every dive. Diver shall indicate by initialing that checklists have been completed before and after each dive. Such documents shall be filed and maintained as permanent project records. No rebreather shall be dived which has failed any portion of the pre-dive check, or is found to not be operating in accordance with manufacturer's specifications. Pre-dive checks shall include all of the following:

- a) Gas supply cylinders full
- b) Composition of all supply and bail-out gases analyzed and documented
- c) Oxygen sensors calibrated
- d) Carbon dioxide canister properly packed
- e) Remaining duration of canister life verified
- f) Breathing loop assembled
- g) Positive and negative pressure leak checks
- h) Automatic volume addition system working
- i) Automatic Oxygen addition systems working
- j) Pre-breathe system for 3 minutes (5 minutes in cold water) to ensure proper Oxygen addition and carbon dioxide removal (be alert for signs of hypoxia or hypercapnia)
- k) Other procedures specific to the model of rebreather used
- l) Documentation of ALL components assembled

- m) Complete pre-dive system check performe
- n) Final operational verification immediately before to entering the water:
  - a. PO<sub>2</sub> in the rebreather is not hypoxic
  - b. Oxygen addition system is functioning;
  - c. Volumetric addition is functioning
  - d. Bail-out life support is functioning

#### *Alternate Life Support System*

The diver shall have reliable access to an alternate life support system designed to safely return the diver to the surface at normal ascent rates, including any required decompression in the event of primary rebreather failure. The complexity and extent of such systems are directly related to the depth/time profiles of the mission. Examples of such systems include, but are not limited to:

- a) Open-circuit bailout cylinders or sets of cylinders, either carried or pre-positioned
- b) Redundant rebreather
- c) Pre-positioned life support equipment with topside support

#### *CO<sub>2</sub> Absorbent Material*

- a) CO<sub>2</sub> absorption canister shall be filled in accordance with the manufacturer's specifications.
- b) CO<sub>2</sub> absorbent material shall be used in accordance with the manufacturer's specifications for expected duration.
- c) If CO<sub>2</sub> absorbent canister is not exhausted and storage between dives is planned, the canister should be removed from the unit and stored sealed and protected from ambient air, to ensure the absorbent retains its activity for subsequent dives.
- d) Long-term storage of carbon dioxide absorbents shall be in a cool, dry location in a sealed container. Field storage must be adequate to maintain viability of material until use.

#### *Consumables (e.g., batteries, Oxygen sensors, etc.)*

Other consumables (e.g., batteries, Oxygen sensors, etc.) shall be maintained, tested, and replaced in accordance with the manufacturer's specifications.

#### *Unit Disinfections*

The entire breathing loop, including mouthpiece, hoses, counterlungs, and CO<sub>2</sub> canister, should be disinfected periodically according to manufacturer's specifications. The loop must be disinfected between each use of the same rebreather by different divers.

### **10.50 Oxygen Rebreathers**

- a) Oxygen rebreathers shall not be used at depths greater than 20 feet.



- b) Breathing loop and diver's lungs must be adequately flushed with pure Oxygen prior to entering the water on each dive. Once done, the diver must breathe continuously and solely from the intact loop, or re-flushing is required.
- c) Breathing loop shall be flushed with fresh Oxygen prior to ascending to avoid hypoxia due to inert gas in the loop.

#### **10.60 Semi-Closed Circuit Rebreathers**

- a) The composition of the injection gas supply of a semi-closed rebreather shall be chosen such that the partial pressure of Oxygen in the breathing loop will not drop below 0.2 atm, even at maximum exertion at the surface.
- b) The gas addition rate of active addition semi-closed circuit rebreather (SCR) (e.g., Draeger Dolphin and similar units) shall be checked before every dive, to ensure it is balanced against expected workload and supply gas FO<sub>2</sub>.
- c) The intermediate pressure of supply gas delivery in active-addition SCR shall be checked periodically, in compliance with manufacturer's recommendations.
- d) Maximum operating depth shall be based upon the FO<sub>2</sub> in the active supply cylinder.
- e) Prior to ascent to the surface the diver shall flush the breathing loop with fresh gas or switch to an open-circuit system to avoid hypoxia. The flush should be at a depth of approximately 30 fsw during ascent on dives deeper than 30 fsw, and at bottom depth on dives 30 fsw and shallower.

#### **10.70 Closed-Circuit Rebreathers**

- a) The FO<sub>2</sub> of each diluent gas supply used shall be chosen so that, if breathed directly while in the depth range for which its use is intended, it will produce an inspired PPO<sub>2</sub> greater than 0.20 atm but no greater than 1.4 atm.
- b) Maximum operating depth shall be based on the FO<sub>2</sub> of the diluent in use during each phase of the dive, so as not to exceed a PO<sub>2</sub> limit of 1.4 atm.
- c) Divers shall monitor both primary and secondary Oxygen display systems at regular intervals throughout the dive, to verify that readings are within limits, that redundant displays are providing similar values, and whether readings are dynamic or static (as an indicator of sensor failure).
- d) The PPO<sub>2</sub> set point shall not be lower than 0.4 atm or higher than 1.4 atm.

## **SECTION 11.00 SCIENTIFIC CAVE AND CAVERN DIVING STANDARD**

This standard helps to ensure all scientific diving in overhead environments is conducted in a manner that will maximize the protection of scientific divers from accidental injury and/or illness and provide the basis allowing the working reciprocity between AAUS organizational members.

If a conflict exists between this standard and other standards in this manual, the information set forth in this standard only takes precedence when the scientific diving being conducted takes place wholly or partly within an underwater cave or cavern environment.

A dive team shall be considered to be cave or cavern diving if at any time during the dive they find themselves in a position where they cannot complete a direct, unobstructed ascent to the surface because of rock formations.

The member organization requires that no person shall engage in scientific cave or cavern diving unless that person holds a recognized certificate/authorization issued pursuant to the provisions of this manual.

The diver must demonstrate to the DCB or its designee that the diver possesses the proper attitude, judgment, and discipline to safety conduct cave and cavern diving in the context of planned operations.

Operational requirements for cave and cavern diving have been established through accident analysis of previous cave diving accidents.

### **11.10 Definitions**

**Alternate Gas Supply** - Fully redundant system capable of providing a gas source to the diver should their primary gas supply fail.

**Bubble Check** - Visual examination by the dive team of their diving systems, looking for o-ring leaks or other air leaks conducted in the water prior to entering a cave. Usually included in the "S" Drill.

**Cave** – A dive shall be considered a cave dive if any one or more of the environmental limits specified in the definition of cavern are exceeded or otherwise not followed. Linear penetrations limits shall not exceed the limits of each diver's training.

**Cave Dive** - A dive, which takes place partially or wholly underground, in which one or more of the environmental parameters defining a cavern dive are exceeded.

**Cavern** - An entrance and first chamber to a cave where:

- a) Sunlight from the entrance is visible to all dive team members at all times during the dive.
- b) Members of the dive team do not pass through any restrictions that don't allow the divers to swim side by side during the dive, nor are there any restrictions between the divers and the most expeditious exit to the surface.
- c) Maximum depth achieved shall not exceed the depth ratings of dive team.

**Cavern Dive** - A dive which takes place partially or wholly underground, in which the all of the following

environmental parameters are met:

- a) Natural sunlight is continuously visible from the entrance.
- b) Environmental conditions will be evaluated by the DSO or designee and appropriate limits incorporated into the dive plan.

Dual Valve Manifold with Isolator Valve - A manifold joining two diving cylinders, that allows the use of two completely independent regulators. If either regulator fails, it may be shut off, allowing the remaining regulator access to the gas in both of the diving cylinders.

Gas Management - Gas planning rule which is used in cave diving environments in which the diver reserves a portion of their available breathing gas for anticipated emergencies (See Rule of Thirds, Sixths).

Guideline - Continuous line used as a navigational reference during a dive leading from the team position to a point where a direct vertical ascent may be made to the surface.

Jump/Gap Reel - Spool or reel used to connect one guide line to another thus ensuring a continuous line to the exit.

Knife/Line Cutter - Small, sharp blade capable of easily cutting a guideline and that is accessible to the diver.

Lava Tube - Type of cave or cavern formed by the surface hardening of a stream of flowing molten rock, which may later become flooded due to static sea level changes.

Line Marker - Any one of several types of markers attached to a guideline, which provides additional navigational information to the dive team, most commonly the direction out to the nearest surface.

Mine Diving - Diving in the flooded portions of a man-made mine. Necessitates use of techniques detailed for cave diving.

Penetration Distance - Linear distance from the entrance of the overhead environment intended or reached by a dive team during a dive at a dive site.

Primary Reel - Initial guideline used by the dive team from open water to maximum penetration or a permanently installed guideline.

Restriction - Any passage through which two divers cannot easily pass side by side while sharing air.

Rule of Thirds - Gas planning rule which is used in cave diving environments in which the diver reserves 2/3's of their breathing gas supply for exiting the cave or cavern.

Rule of Sixths - Air planning rule which is used in cave or other confined diving environments in which the diver reserves 5/6's of their breathing gas supply (for DPV use, siphon diving, etc.) for exiting the cave or cavern.

Safety Drill - ("S" Drill) - A brief gas sharing, equipment evaluation, dive plan, and communication exercise carried out prior to entering a cave or cavern dive by the dive team.

Safety Reel - Secondary reel used as a backup to the primary reel, usually containing 150 feet of guideline

that is used in an emergency.

Scientific Cave or Cavern Diver In Training - Authorized to dive in the cave or cavern environment under the direct supervision of qualified instructional personnel for training purposes only.

Scientific Cavern Diver - Authorization to dive in an overhead environment as defined in cavern. Scientific

Cave Diver - Authorization to dive in an overhead environment as defined in cave.

Sidemount Diving - A diving mode utilizing two independent SCUBA systems carried along the sides of the diver's body; either of which always has sufficient air to allow the diver to reach the surface unassisted.

Siphon - Cave into which water flows with a generally continuous in-current.

Solution Cave - Cave formed in carbonate or carbonate-cemented bedrock, formed by the dissolution of the rock by groundwater.

Spring - Cave with water flowing with a generally continuous outflow.

Sump - An area in a dry cave that can no longer be negotiated without the use of diving equipment.

Well - A vertical or nearly vertical shaft, usually manmade, through which a diver can access a dive site.

### **11.20 Cave and Cavern Environment Hazards**

- a) Current/Flow - Underwater caves have currents that vary in strength and direction. Of particular note is a condition known as siphoning. Siphoning caves have flow or current directed into the cave. This can cause poor visibility as a result of mud and silt being drawn into the cave entrance.
- b) Silt - The presences of silt, sand, mud, clay, etc. on the cave floor can cause visibility to be reduced to nothing in a very short time.
- c) Restrictions - Any passage through which two divers cannot easily pass side by side while sharing air make air sharing difficult.
- d) Cave-ins – A cave collapses and blocks the exit. Cave-ins are a normal part of cave evolution; however experiencing a cave-in during diving operations is extremely unlikely.

### **11.30 Minimum Experience and Training Requirements**

*Cavern Diver:*

- a) Prerequisites
  - a. The applicant for training shall have met the requirements in Section 5.00 of the AAUS *Standards for Scientific Diving Authorization and Operation of Scientific Diving Programs*, fourth edition (2003), and hold as a minimum a scientific diver authorization.
- b) Cavern Training

The applicant is to participate in the following areas of training, or their equivalent:

  - a. Classroom Lecture and Critique—The applicant shall participate in classroom discussion or

equivalent type activities covering these topics: Policy for cavern diving, cavern environment and environmental hazards, accident analysis, psychological considerations, equipment, body control, communications, cavern diving techniques, navigation and guidelines, dive planning, cave geology, cave hydrology, cave biology, and emergency procedures.

- b. Land Drills – The applicant shall participate in drills above water using the guideline and reel. Drills are to emphasize proper use of the reel, techniques and considerations for laying a guideline, guideline following, buddy communication, and emergency procedures.
- c. Cavern Dives – A minimum of four (4) cavern dives, preferably to be conducted in a minimum of two (2) different caverns. Skills the applicant should demonstrate include: Safety drill (S-drill), gear matching, bubble check prior to entering the cavern on each dive, proper buoyancy compensator use, proper trim and body positioning, hovering and buoyancy with hand tasks, specialized propulsion techniques (modified flutter kick, modified frog kick, pull and glide, ceiling walk or shuffle), proper guideline and reel use, ability to follow the guideline with no visibility, sharing air while following a guideline, and sharing air while following the guideline with no visibility light and hand signal use, and ability to comfortably work in a cavern without assistance.
- d. Written Examination - A written evaluation approved by the DCB with a predetermined passing score, covering concepts of both classroom and practical training is required.

### *Cave Diver*

#### a) Prerequisites

- a. The applicant for training shall hold as a minimum a cavern diver permit.

#### b) Cave Training

The applicant is to participate in the following areas of training, or their equivalent:

- a. Classroom Lecture and Critique—The applicant shall participate in classroom discussion or equivalent type activities covering these topics: Review of the topics listed in cavern diver training and differing techniques and procedures used in cave diving, additional equipment procedures used in cave diving, cave diving equipment configurations, procedures for conducting diving operations involving complex navigation and use of line markers, advanced gas management and a thorough review of dive tables, decompression tables, and decompression theory.
- b. Land Drills – The applicant shall participate in drills above water included in cavern training. Drills are to emphasize proper use of the reel in lost diver procedures, as well as line placements and station location as required for surveying.
- c. Cave Dives – A minimum of twelve (12) cave dives, to be conducted in a minimum of four (4) different cave sites with differing conditions recommended. Skills the applicant should demonstrate include: Review of skills listed in cavern training, and special techniques in buoyancy control, referencing and back-up navigation, air sharing in a minor restriction using a single file method, special propulsion techniques in heavy outflow, anti-silting techniques, line jumping techniques and protocols, surveying, and ability to critique their dives. Emergency procedures training shall include proficiency in lost line, lost diver, gas sharing, light failure, valve manipulation, and no/low visibility situations.
- d. Written Examination - A written evaluation approved by the DCB with a predetermined passing score, covering concepts of both classroom and practical training is required.

## **11.40 Equipment Requirements**

SCUBA equipment shall be carried whenever the planned penetration distances are such that an emergency swimming ascent is not theoretically possible.

#### *Cavern Diving Equipment*

- a) The following equipment shall be required, in excess of that detailed for open water SCUBA diving in Section 3.00. Each member of the dive team shall have all of the following:
  - a. At minimum, a single tank equipped with an “H” valve or an alternate air supply.
  - b. A BCD capable of being inflated from the tank.
  - c. Slate and pencil.
  - d. Two battery powered secondary lights of an approved type.
  - e. Knife or line cutter.
  - f. One primary reel of at least 350 feet for each team.
  - g. No snorkel shall be worn while inside underwater cave or cavern.

#### *Cave Diving Equipment*

- a) The following equipment shall be required, in excess of that detailed for cavern diving: Each member of the dive team shall have all of the following:
  - a. Cylinders with dual orifice isolation valve manifold or independent SCUBA systems each capable of maintaining enough gas for the diver during exit and ascent to the surface.
  - b. Two completely independent regulators, at least one of each having submersible tank pressure gauge, a five foot or longer second stage hose, low pressure inflator for the BCD.
  - c. A primary light with sufficient burn time for the planned dive.
  - d. Two backup lights with sufficient burn time for the planned dive.
  - e. Safety reel with at least 150 feet of line.
  - f. Appropriate submersible dive tables and/or dive computer (computers w/ backup tables).
  - g. Line markers.
  - h. No snorkel shall be worn while inside underwater cave or cavern.

### **11.50 Operational Requirements and Safety Protocols**

All members of the dive team must have met all the applicable sections of the AAUS manual and be authorized for that type of diving by the DCB before conducting scientific cave dives.

#### *Cavern Diver Procedures*

- a) Cavern diving shall not be conducted at depths greater than 100 feet.
- b) Dive teams shall perform a safety drill prior to each cave or cavern penetration that includes equipment check, gas management, and dive objectives.
- c) Each team within the cavern zone must utilize a continuous guideline appropriate for the environment leading to a point from which an uninterrupted ascent to the surface may be made.
- d) Gas management must be appropriate for the planned dive with special considerations made for DPV's, siphon diving, rebreathers, etc.
- e) The entire dive team is to immediately terminate the dive whenever any dive team member feels an unsafe condition is present.

### *Cave Diving Procedures*

- a) Dive teams shall perform a safety drill prior to each cave or cavern penetration that includes equipment check, gas management, and dive objectives.
- b) Diver teams must run or follow a continuous guideline from the surface pool to maximum penetration.
- c) Gas management must be appropriate for the planned dive with special considerations made for DPV's, siphon diving, rebreathers, etc.
- d) Each diver must carry one primary and two back up lights.
- e) Divers utilizing side mount diving or other dual independent diving systems must have the approval of the Diving Safety Officer or his/her designee.
- f) The entire dive team is to immediately terminate the dive whenever any dive team member feels an unsafe condition is present.

## SECTION 12.00 DIVE COMPUTER GUIDELINES

- a) Only those makes and models of dive computers specifically approved by the Diving Control Board (DCB) may be used.
- b) Any diver desiring the approval to use a dive computer as a means of determining decompression status must apply to the DCB, complete an appropriate practical training session and pass a written examination.
- c) Each diver relying on a dive computer to plan dives and indicate or determine decompression status must have his/her own unit.
- d) On any given dive, both divers in the buddy pair must follow the most conservative dive computer.
- e) If the dive computer fails at any time during the dive, the dive must be terminated and appropriate surfacing procedures should be initiated immediately.
- f) A diver should not dive for 18 hours before activating a dive computer to use it to control their diving.
- g) Once the dive computer is in use, it must not be switched off until it indicates complete out gassing has occurred or 18 hours have elapsed, whichever comes first.
- h) When using a dive computer, non-emergency ascents are to be at a rate specified for the make and model of dive computer being used.
- i) Whenever practical, divers using a dive computer should make a stop between 10 and 30 feet for 5 minutes, especially for dives below 60 fsw.
- j) Multiple deep dives require special consideration.



## **SECTION 13.00 OTHER DIVING TECHNOLOGY**

Certain types of diving, some of which are listed below, require equipment or procedures that require training. Supplementary guidelines for these technologies are in development by AAUS. Organizational members using these must have guidelines established by their Diving Control Board. Divers shall comply with all SCUBA diving procedures in this standard unless specified.

### **13.10 Blue Water Diving**

Blue water diving is defined as diving in open water where the bottom is generally greater than 200 feet deep. It requires special training and diving techniques. Specific suggested guidelines are outlined in “Blue Water Diving Guidelines” (California Sea Grant Publ. No. T-CSGCP-014).

### **13.20 Ice And Polar Diving**

Divers planning to dive under ice or in polar conditions should use the following: “Guidelines for Conduct of Research Diving”, National Science Foundation, Division of Polar Programs, 1990.

### **13.30 Saturation Diving**

If using open circuit compressed air SCUBA in saturation diving operations, divers shall comply with the saturation diving guidelines of the organizational member.

### **13.40 Hookah**

While similar to Surface Supplied in that the breathing gas is supplied from the surface by means of a pressurized hose, the supply hose does not require a strength member, pneumofathometer hose, or communication line. Hookah equipment may be as simple as a long hose attached to a standard SCUBA cylinder supplying a standard SCUBA second stage. The diver is responsible for the monitoring his/her own depth, time, and diving profile.

### **13.50 Surface Supplied Diving**

Dives where the breathing gas is supplied from the surface by means of a pressurized umbilical hose. The umbilical generally consists of a gas supply hose, strength member, pneumofathometer hose, and communication line. The umbilical supplies a helmet or full-face mask. The diver may rely on the tender at the surface to keep up with the divers’ depth, time and diving profile.

## **APPENDIX 1**

### **DEFINITION OF TERMS**

Air Sharing - Sharing of an air supply between divers.

ATA(s) - “Atmospheres Absolute”, Total pressure exerted on an object, by a gas or mixture of gases, at a specific depth or elevation, including normal atmospheric pressure.

Breath-hold Diving - A diving mode in which the diver uses no self-contained or surface-supplied air or Oxygen supply.

Buddy Breathing - Sharing of a single air source from one single regulator between divers.

Buddy Diver - Second member of the dive team.

Buddy System - Two comparably equipped SCUBA divers in the water in constant communication.

Buoyant Ascent - An ascent made using some form of positive buoyancy.

Burst Pressure - Pressure at which a pressure containment device would fail structurally.

Certified Diver - A diver who holds a recognized valid certification from an internationally recognized certifying agency.

Controlled Ascent - Any one of several kinds of ascents including normal, swimming, and air sharing ascents where the diver(s) maintain control so a pause or stop can be made during the ascent.

Cylinder - A pressure vessel for the storage of gases.

Decompression Chamber - A pressure vessel for human occupancy. Also called a hyperbaric chamber.

Decompression Sickness - A condition with a variety of symptoms, which may result from gas, and bubbles in the tissues of divers after pressure reduction.

Dive - A descent into the water, an underwater diving activity utilizing compressed gas, an ascent, and return to the surface.

Dive Computer- A microprocessor based device which computes a diver’s theoretical decompression status, in real time, by using pressure (depth) and time as input to a decompression model, or set of decompression tables, programmed into the device.

Dive Location - A surface or vessel from which a diving operation is conducted.

Dive Site - Physical location of a diver during a dive.

Dive Table - A profile or set of profiles of depth-time relationships for ascent rates and breathing mixtures to be followed after a specific depth-time exposure or exposures.

Diver - An individual in the water who uses an apparatus, including snorkel, which supplies breathing gas

at ambient pressure.

**Diver-In-Training** - An individual gaining experience and training in additional diving activities under the supervision of a dive team member experienced in those activities.

**Diver-Carried Reserve Breathing Gas** - A diver-carried independent supply of air or mixed gas (as appropriate) sufficient under standard operating conditions to allow the diver to reach the surface, or another source of breathing gas, or to be reached by another diver.

**Diving Mode** - A type of diving required specific equipment, procedures, and techniques, for example, snorkel, SCUBA, surface-supplied air, or mixed gas.

**Diving Control Board (DCB)** - Group of individuals who act as the official representative of the membership organization in matters concerning the scientific diving program (Section 1.24).

**Diving Safety Officer (DSO)** - Individual responsible for the safe conduct of the scientific diving program of the membership organization (Section 1.20).

**Emergency Ascent** - An ascent made under emergency conditions where the diver exceeds the normal ascent rate.

**Enriched Air (EANx)** - See “Nitrox.”

**Equivalent Air Depth (EAD)** - Depth at which air will have the same Nitrogen partial pressure as the Nitrox mixture being used. This number, expressed in units of feet seawater or saltwater, will always be less than the actual depth for any enriched air mixture.

**fN<sub>2</sub>** - Fraction of Nitrogen in a gas mixture, expressed as either a decimal or percentage, by volume. **fO<sub>2</sub>** - Fraction of Oxygen in a gas mixture, expressed as either a decimal or percentage, by volume.

**FFW** – Feet or freshwater, or equivalent static head.

**FSW** - Feet of seawater, or equivalent static head.

**Hookah** - While similar to Surface Supplied in that the breathing gas is supplied from the surface by means of a pressurized hose, the supply hose does not require a strength member, pneumofathometer hose, or communication line. Hookah equipment may be as simple as a long hose attached to a standard SCUBA cylinder supplying a standard SCUBA second stage. The diver is responsible for the monitoring his/her own depth, time, and diving profile.

**Hyperbaric Chamber** - See decompression chamber.

**Hyperbaric Conditions** - Pressure conditions in excess of normal atmospheric pressure.

**Lead Diver** - Authorized scientific diver with experience and training to conduct the diving operation.

**Maximum Working Pressure** - Maximum pressure to which a pressure vessel may be exposed under standard operating conditions.

**Organizational Member** - An organization which is a current member of the AAUS, and which has a program, which adheres to the standards of the AAUS as, set forth in the AAUS Standards for Scientific Diving Authorization and Operation of Scientific Diving Programs.

**Mixed Gas (MG)** - Gas mixes containing proportions greater than 1% by volume of an inert gas other than Nitrogen.

**Mixed-Gas Diving** - A diving mode in which the diver is supplied in the water with a breathing gas other than air.

**Maximum Operating Depth (MOD)** - Usually determined as the depth at which the  $pO_2$  for a given gas mixture reaches a predetermined maximum.

**MSW** - Meters of seawater or equivalent static head.

**Nitrox** - Any gas mixture comprised predominately of Nitrogen and Oxygen, most frequently containing between 21% and 40% Oxygen. Also be referred to as Enriched Air Nitrox, abbreviated EAN.

**NOAA Diving Manual**: Refers to the *NOAA Diving Manual, Diving for Science and Technology*, 2001 edition. National Oceanic and Atmospheric Administration, Office of Undersea Research, US Department of Commerce.

**No-Decompression Limits (NDL)** - Depth-time limits of the “no-decompression limits and repetitive dive group designations table for no-decompression air dives” of the U.S. Navy Diving Manual or equivalent limits.

**Normal Ascent** - An ascent made with an adequate air supply at a rate of 30 feet per minute or less.

**Oxygen Clean** - All combustible contaminants have been removed.

**Oxygen Compatible** - A gas delivery system that has components (o-rings, valve seats, diaphragms, etc.) that are compatible with Oxygen at a stated pressure and temperature.

**Oxygen Service** - A gas delivery system that is both Oxygen clean and Oxygen compatible.

**Oxygen Toxicity Unit - OTU**

**Oxygen Toxicity** - Any adverse reaction of the central nervous system (“acute” or “CNS” Oxygen toxicity) or lungs (“chronic”, “whole-body”, or “pulmonary” Oxygen toxicity) brought on by exposure to an increased (above atmospheric levels) partial pressure of Oxygen.

**Pressure-Related Injury** - An injury resulting from pressure disequilibrium within the body as the result of hyperbaric exposure. Examples include: decompression sickness, pneumothorax, mediastinal emphysema, air embolism, subcutaneous emphysema, or ruptured eardrum.

**Pressure Vessel** - See cylinder.

**$pN_2$**  - Inspired partial pressure of Nitrogen, usually expressed in units of atmospheres absolute.

pO<sub>2</sub> - Inspired partial pressure of Oxygen, usually expressed in units of atmospheres absolute.

PSI - Unit of pressure, “pounds per square inch.

PSIg - Unit of pressure, “pounds per square inch gauge.

Recompression Chamber - see decompression chamber.

Scientific Diving - Scientific diving is defined (29CFR1910.402) as diving performed solely as a necessary part of a scientific, research, or educational activity by employees whose sole purpose for diving is to perform scientific research tasks.

SCUBA Diving - A diving mode independent of surface supply in which the diver uses open circuit self-contained underwater breathing apparatus.

Standby Diver - A diver at the dive location capable of rendering assistance to a diver in the water.

Surface Supplied Diving - Dives where the breathing gas is supplied from the surface by means of a pressurized umbilical hose. The umbilical generally consists of a gas supply hose, strength member, pneumofathometer hose, and communication line. The umbilical supplies a helmet or full-face mask. The diver may rely on the tender at the surface to keep up with the divers' depth, time and diving profile.

Swimming Ascent - An ascent that can be done under normal or emergency conditions accomplished by simply swimming to the surface.

Umbilical - Composite hose bundle between a dive location and a diver or bell, or between a diver and a bell, which supplies a diver or bell with breathing gas, communications, power, or heat, as appropriate to the diving mode or conditions, and includes a safety line between the diver and the dive location.

Working Pressure - Normal pressure at which the system is designed to operate.

## APPENDIX 2

### DIVING EMERGENCY MANAGEMENT PROCEDURES

#### GENERAL POLICY

##### Introduction

1. Development of exact procedures to cover all possible emergency situations can not be accomplished in this manual because of the immense number of variables involved (e.g., differences in diving location, personnel, available medical facilities, transportation, etc.).
2. This section is intended to serve as a planning guide for University divers to formulate specific procedures for their operations. Supervisory personnel, under direction of the Diving Safety Officer, must use judgment in selecting procedures which best suit the nature of their operation.
3. Detailed accident management and first aid techniques may be found in the NOAA Diving Manual, Red Cross manuals, DAN First Aid manual, and many other approved publications.

##### Preparedness

1. All supervisors and team members must be prepared to respond properly in the event of an accident. Prompt emergency procedures can reduce the residual effects on the victim and can possibly save a life.
2. Periodic retraining and routine practice are essential elements in emergency preparedness; emergency drills are encouraged.
3. The importance of prevention through operations planning, following safety regulations, and using common sense can not be overemphasized.

#### ON-SITE ACCIDENT MANAGEMENT

##### Rescue/first aid

1. The persons nearest the victim (in scuba & usually the buddy), will initiate rescue/recovery procedures.
2. The rescuer will signal for assistance (voice, whistle, flare, etc.)
3. If the victim is not breathing, the rescuer will immediately start basic life support in the water. Resuscitation must be continued with a minimum of interruption while removing the diver from the water and not be discontinued until the victim resumes breathing, is turned over to a higher authority, or is pronounced dead by a physician.
4. The Lead Diver, next senior diver, or ship's captain will take charge of the scene and delegate tasks to other responsible individuals. Other team members, if available on site will be dispatched by the Lead Diver to assist in the rescue efforts.
5. If a gas embolism or decompression sickness is suspected and the victim is breathing, immediately begin prescribed first aid (supine position, administer oxygen, fluids (water) if conscious and alert, treat for shock, and keep under constant observation). See Diving Accident Management manual (Appendix D).

##### Summoning Aid: Miami area

1. Divers in the Miami area should radio US Coast Guard on VHF channel 16 or local EMS by cellular phone (911) and indicate that you have a "scuba diving emergency and need a recompression chamber".
2. Inform the USCG/EMS that you are evacuating the victim to the nearest accessible dock, where that dock is, and they should contact the South Florida Hyperbaric Medical Center 1 800 NO BENDS or Jackson Memorial Hospital (305) 585-3483 to activate the recompression chamber.
3. Monitor your VHF or keep your cellular phone on and stay in contact with the USCG/EMS for the duration of the emergency.
4. The USCG/EMS may direct you to take the victim somewhere besides the place you indicated. Cooperate with them.
5. Attempt to contact the RSMAS Diving Safety Office via VHF or cellular phone.

6. If unable to contact USCG on VHF or cellular phone, use VHF marine operator on channel 24 or 25 to place a telephone call to South Florida Hyperbaric Medical Center 1 800 NO Bends, Jackson Memorial Hospital (305) 585-3483 or the Dade County Fire Rescue at 911.

At Sea on Research Vessels:

1. Divers:
  - a. Immediately advise ship's Master of the situation and request assistance as needed.
  - b. Administer first aid to victim (oxygen, supine position, fluids (water) if conscious and alert, treat for shock, monitor vitals).
  - c. Consult emergency plan for instructions.
  - d. Keep ship's captain apprised of the situation as it progresses.
  - e. Conduct neurological exam on patient, if possible, and record results on exam form (Appendix D).
2. Ship's Master:
  - a. Contact the Divers Alert Network ((DAN) see cruise emergency plan) and be specific about the accident: "this is a scuba diving accident requiring a recompression chamber". DAN will provide nearest operational chamber info. and will help coordinate transportation.
  - b. Stay in contact with divers and get neurological exam results from them on the patient.
  - c. Give physician at DAN as accurate a description as possible about the condition of the patient.
  - d. Make plans for possible evacuation of patient to chamber, whether it be helicopter evac or steaming to port.
  - e. Obtain important papers from the victim, i.e., passport, insurance, medical history (drug allergies, etc.).
3. Persons/organizations to be notified:
  - a. victim's family
  - b. DAN (for medical advice, evacuation procedures)
  - c. UM/RSMAS authorities (Diving Safety Officer)
  - d. recompression chamber

On-site Care of Diving Casualty

1. Follow Accident Management steps found in the Dive Accident Management manual (Appendix D) of this manual.
2. If time & circumstances permit, perform an initial neurological examination (Appendix D).
3. If an asymptomatic emergency is managed at the scene & hospitalization or professional medical attention are not required:
  - a. provide victim with emergency numbers for diving physician, local medical facility, etc., and
  - b. do not let the victim drive or be alone for the next six hours.
4. Any person resuscitated at the dive site MUST be transported to a medical facility for follow up examination/treatment, preferably by a hyperbaric physician.

Additional On-Site Procedures While Awaiting Aid/Transport:

1. Recall all divers in the water, terminate all diving operations, secure equipment, be certain all dive team members are accounted for.
2. Non-involved dive team members shall stand by and not interfere with emergency efforts.
3. Diving operations shall not resume until the appropriate emergency equipment and personnel are back at the dive site.
4. Designate team members to control crowds or bystanders, keep non-essential personnel away from the victim and first aid providers, instruct dive team members not to mingle with bystanders and not to discuss the accident with anyone (especially in a beach/shore operation), do not allow any dive team members to leave until dismissed by the Lead Diver or Diving Safety Officer. In fatal or serious accidents authorization from local law enforcement officers will be required for dismissal of witnesses.

EMERGENCY EVACUATION GUIDELINES

General: The following medical evacuation information should be forwarded with the patient. If possible, take time to explain the following steps to the physician or paramedic. Do not assume they

understand the reasons why procedures such as administration of oxygen to a diving casualty must be performed. Call the Divers Alert Network (919) 684-8111 (you can also call South Florida Hyperbaric Medical Center 800-662-3637 (800 NO BENDS)) for medical consultation if doubt exists that the physician/hospital possess the competence to handle a diving casualty.

1. Maintain breathing and heart functions, ensure an open airway. If CPR is being administered, there must be an absolute minimum of interruption during transfer.
2. Keep patient on oxygen and in supine position during transport. (Appendix D)
3. Ensure paramedics/physician understand why the patient must be taken to a recompression chamber, and why #2 is important.
4. Do not stop giving oxygen to patient unless there is a need to reopen the airway, or patient show signs of oxygen convulsions.
5. Treat for shock (lay patient supine, elevate patient's legs, keep patient comfortable).
6. Do not give any pain killing drugs.
7. Instruct flight crews to fly as low as possible (below 1000 ft. is preferred).
8. If possible, the dive buddy should also be transported with the victim because he/she may also need recompression and can give valuable information about the dive profile.
9. A complete history of all events leading to the accident must be forwarded with the patient.
10. Victim's dive gear should be properly tagged and sent with the victim or at least set aside without tampering, especially if the accident was fatal.

Evacuation by Air: Each helicopter evacuation presents unique problems. Knowing what to expect and the procedures to follow, however, can save time, effort, and perhaps a life.

1. Request a helicopter with a medic crew and oxygen. In your request, follow guidelines in 8.31.
2. Try to establish communications with the helicopter.
3. If possible, maintain a speed of 10-15 knots into wind about 20 degrees off the port bow.
4. Put all antennas down, if possible, without losing communications.
5. Secure all loose objects on or around the decks because of the strong winds generated by the helicopter.
6. Make sure the patient is ready in advance of the transfer.
7. Signal the pilot when all is ready, using hand signals in daylight and flashlight signals at night.
8. Do not secure the trail line, basket, or any cable from the aircraft to the boat.
9. Always let the lifting device (stretcher) touch the boat before handling it, to prevent electric shock.
10. Place a lifejacket on patient and tie them in basket face up.
11. Attach personal information such as name, address, age, next of kin, what happened, medication administered, drug allergies.

## LEGAL CONSIDERATIONS

**Responsibility:** Serious accidents and fatalities often lead to legal actions. Each diver has a responsibility as a representative of the University, to act in a responsible manner, both for the benefit of the University and him/herself.

**Guidelines for serious accidents:**

1. Contact local law enforcement authorities
2. Be polite but firm regarding interviews and questions. If approached, simply indicate that information will be made available through the University's Diving Safety Office. Remember that any statement made under stress may later cause considerable problems for members of the dive team including yourself, University, and victim.
3. The Lead Diver should serve as spokesman for the group.
4. Give only factual information to authorities. Avoid expressing opinions or conclusions under stress.
5. Have each dive team member prepare detailed statements of the facts. Do it as soon as possible the day of the accident, not a week later.
6. The Lead Diver should complete the Accident Report form for the Diving Control Board.



**EMERGENCY ASSISTANCE PHONE NUMBERS FOR THE MIAMI AREA**

**RECOMPRESSION CHAMBERS:**

At Mercy Hospital (Miami, FL).....	1-800-NO BENDS
Mercy Hospital Hyperbaric Dept.....	305.854.0300
	305.854.2466
Mercy Hospital Emergency Room.....	305.285.2171
UM/Jackson Memorial Hospital Hyperbaric Dept. (Miami).....	305.585.3483
UM/Jackson Memorial Hospital Emergency Room.....	305.585.1111
Dade County Fire Rescue.....	911
Diver's Alert Network (DAN) Emergency.....	1.919.684.8111
Diver's Alert Network (DAN) Non-Emergency.....	1.919.684.2948

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**HOSPITALS:**

Mercy Hospital Hyperbarics Dept.....	305.854.0300
UM/Jackson Memorial Hospital Emergency Room.....	305.585-1111

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**AMBULANCE:**

Dade County Fire Rescue.....	911
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**AIR TRANSPORTATION:**

US Coast Guard, District Operations Off., Miami, FL.....	305.536.5611
VHF Radio.....	channel 16
USCG Emergency Phone, Miami, FL.....	305.535.4313

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**POLICE:**

General, Miami.....	911
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Key Biscayne police (non- emergency).....	305.365.3013
Key Biscayne police (24 hrs.).....	305.585.6666

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**UNIVERSITY OF MIAMI:**

RSMAS Diving Safety Office.....	305.421.4107
Rick Gomez.....	305.338.1445
Marine Dept.....	305.421.4880
RSMAS General Information.....	305.421.4000

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**DIVING ACCIDENT MANAGEMENT MANUAL**

**INTRODUCTION**

The information contained in this manual is a simplified system of identifying and stabilizing diving accident victims and facilitating entry into the hyperbaric trauma care system. Divers may ignore the mild symptoms of bubble trouble in the early stages and by doing so they may eventually have more serious symptoms. Although primarily intended as a treatment guide for University diving operations in the field, it can also be used to insure that paramedics, physicians, Coast Guard and other assisting personnel understand and perform the specialized procedures for handling diving accident cases.

Portions of this first aid manual have been excerpted from:

-"Underwater Diving Accident Manual", Diving Alert Network, Duke University, Durham, NC, 1994.

-"NOAA Diving Manual", US Dept. of Commerce, US Government Printing Office, Wash, DC, 1991.

## **DIVER'S ALERT NETWORK**

The Divers Alert Network was formed in 1981 to assist in the treatment of underwater diving accidents by providing a 24 hour telephone emergency call number: **(919) 684-8111**. This number can be called collect in diving emergencies. The call is received at Duke University Medical Center where it is connected with on-call physicians experienced in diving accident treatment. These physicians can deal with initial treatment of the accident and supervise referral to appropriate regional coordinators. If there is any doubt whatsoever regarding the expertise of an attending EMT, physician, hospital or transport agency in handling a diving accident victim, call DAN number without hesitation. Be prepared to give background information regarding the accident, name and telephone number or the physician/facility.

## **THE UNDERWATER DIVING ACCIDENT VICTIM**

Arterial gas embolism (AGE) and decompression sickness (DCS), also known as the two most frequent serious scuba-related accidents. AGE, also known as air embolism, occurs when bubbles entering the bloodstream through damaged lung tissue obstruct the blood flow to an area of the brain, heart, or spinal cord. Decompression sickness, also known as the "bends", is the syndrome of joint pains (the bends), paralysis, numbness, and other symptoms resulting from insufficient decompression or surfacing too rapidly from a dive. If not treated, both conditions can be fatal.

An underwater diving accident victim may be any person who has been breathing air underwater regardless of depth or time. Gas embolism can occur in as little as four (4) feet of water if one ascends holding his/her breath. Even a well-trained diver may encounter problems because of respiratory problems. Asthma, broncholithiasis, congenital or acquired cysts, emphysema, fibrosis, tuberculosis, infection and obstructive lung diseases may result in air-trapping in the alveoli during ascent. The expansion of trapped air may be sufficient to rupture air spaces and escaping air may cause emphysema of the lungs, mediastinum or neck. More serious problems of pneumothorax or arterial gas embolism may also result.

Decompression sickness can occur in any individual who violates the decompression tables either willingly or unintentionally when surfacing from depths greater than 30 feet. Cases have also been reported of DCS when divers were not exceeding no-decompression limits.

To insure a successful treatment, instructors, dive masters, paramedics, emergency room personnel, and physicians

must be able to recognize the problem and begin the proper treatment while arranging entry into the hyperbaric trauma system.

In any situation suggesting a diving accident, the primary question is "Did the subject breathe compressed gas underwater?" If the answer is "yes", or if the victim is unconscious then the subject must be regarded as a diving accident victim. The treatment procedure must be initiated immediately. This includes basic life support, administering oxygen, supine position, and immediate evacuation to the recompression chamber complex.

### **Mild symptoms**

Mild symptoms may respond to oxygen treatment at the scene. Fatigue (mild), skin rash, and weakness are considered a minor symptom, but frequently require recompression and are handled as a severe symptom in the flow chart.

If the diver surfaces from a dive and behaves in an unusual manner, appears confused, or has fatigue, weakness or skin rash, he may have early symptoms of a diving accident.

Immediately place the diver in the supine position and administer oxygen. Refer to the flow chart and follow through. Oxygen treatment often relieves the symptoms or prevents them from getting worse. The victim will probably deny the possibility of having a problem and may refuse oxygen. Good judgment should prevail and the diver should receive treatment. If the symptoms appear relieved after an interval of oxygen treatment, do not remove the oxygen immediately as the symptoms may recur. The victim should continue to receive 100% oxygen for as long as the supply will last. Follow the flow chart for further instructions.

### **Severe symptoms**

Severe symptoms consisting of joint pain, weakness or paralysis, staggering, respiratory difficulties or unconsciousness require immediate treatment and evacuation into the hyperbaric trauma system. Cardiopulmonary resuscitation will be required if the victim has no pulse or respiration. If a person at any time within 24 hours after a dive shows any severe symptoms indicated on the flow chart, immediately provide the victim with oxygen and place in the supine position. Monitor pulse and respiration and follow the instructions in the flow chart until evacuation to the recompression chamber has been accomplished.

It is important to remember that because these signs and symptoms can develop hours after diving, the patient may show up in a hospital emergency room or other medical facility in the community. For this reason, it is important for paramedics and physicians to recognize the symptoms and to understand this problem so that the proper

procedure can be initiated. It is also extremely important that any person delivering a diving accident patient to a medical facility PROVIDE THAT FACILITY WITH THIS MANUAL AND THE COMPLETE HISTORY RECORDED ON THE FORMS INCLUDED IN THIS MANUAL. The manual should stay with the patient until he reaches the hyperbaric trauma center in order to provide those caring for the patient with full information concerning the accident.

### GAS EMBOLISM

As a diver surfaces without exhaling, air trapped in the lungs expands and may rupture lung tissue releasing gas bubbles into the circulatory system where they may be distributed to the body tissues. The ascending diver is normally in a vertical position and the bubbles tend to travel upward toward the brain, eventually reaching a small artery blocking circulation. The effects of halting circulation to the brain are critical and require immediate treatment. Symptoms of embolism may be present when the victim reaches the surface or within a few minutes afterwards.

CAUSES:                    Holding breath during ascent while breathing compressed air  
                                 Lung disease causing air trapping  
                                 Diving with cold, chest congestion  
                                 Airway obstruction from foreign object in the mouth; gum, etc.

SYMPTOMS:                Unconsciousness within 3-5 minutes of surfacing from a dive  
                                 Dizziness, staggering  
                                 Visual disturbances  
                                 Paralysis  
                                 Bloody froth from the mouth/nose  
                                 Respiratory arrest

*Note: Symptoms usually appear within 15 minutes after surfacing.*

PREVENTION: Always breathe normally during ascent  
Get a periodical medical examination by a hyperbaric physician  
Do not dive with cold or chest congestion  
Do not chew gum, tobacco, etc. while diving

TREATMENT: Supine position  
Administer 100% oxygen  
Administer fluids(water), to conscious, alert victim only.  
Do initial neurological exam  
Evacuate to recompression chamber/hospital ASAP  
DO NOT ATTEMPT IN-WATER TREATMENT

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### DECOMPRESSION SICKNESS

Decompression sickness (bends) is the result of inadequate decompression following a dive. While immediate recompression is not usually a matter of life or death as with air embolus, the quicker recompression is initiated, the better the rate and extent of recovery. The body tissues absorb gas in proportion to the surrounding pressure (depth) and as long as the diver remains at pressure (depth), the gas present no problem. If the pressure is released too quickly (surfacing too rapidly or omitting required decompression), the inert gas comes out of solution and forms bubbles in the tissues and blood stream.

CAUSES: Inadequate decompression caused by-  
Rapid ascent, exceeding 60 ft./minute  
Omitted decompression stop  
Ignoring predisposing factors, i.e., obesity, dehydration, cold-arduous dives, flying too soon after diving, over-heating or overexertion after a dive.

SYMPTOMS: Joint pain  
Extreme fatigue

Paralysis, numbness

Unconsciousness

Dizziness, staggering

**Note:** Symptoms usually occur between 15 minutes and 6 hours after the dive, but can be delayed for up to 24 hours or more.

PREVENTION: Do not dive if dehydrated, hungover, intoxicated, overly fatigued

Conservative use of dive tables, including safety stops on ascents.

If overweight be even more conservative in using tables

Avoid exertion and over-heating after a dive, (hot showers, pulling anchor)

TREATMENT: Supine position/legs elevated

Administer 100% oxygen

Administer fluids(water), to conscious, alert victim only.

Do initial neurological exam

Evacuate to recompression chamber/hospital ASAP

DO NOT ATTEMPT IN-WATER TREATMENT

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### CARBON DIOXIDE EXCESS

CAUSES: Over-exertion

Skip breathing

Hyperventilation; improper breathing pattern

Loss of air supply

SYMPTOMS: Labored or rapid breathing

Headache, dizziness, weakness, nausea

Unconsciousness

PREVENTION: Stop, rest, breathe normally, surface if breathing becomes labored

Avoid causes listed above

TREATMENT: Give oxygen

ABC's, CPR, if required

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### PNEUMOTHORAX

Air enters the chest cavity causing lungs to collapse.

CAUSES: Same as Gas embolism

SYMPTOMS: Shortness of breath

Sharp pain in chest

SIGNS: Rapid shallow breathing

Blueness of skin, lips, fingernails

Lungs sound different from one side to the other

PREVENTION: Same as Gas embolism

TREATMENT: ABC's, give O<sub>2</sub>, treat for shock, Do NOT use recompression without a chest tube. Physician will insert chest tube to with draw air and re-inflate lung

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## MEDIASTINAL EMPHYSEMA

Air released into tissues surrounding the heart.

CAUSES: Same as Gas embolism

SYMPTOMS: Faintness  
Shortness of breath, difficulty breathing  
Pain under breastbone

PREVENTION: Same as Gas embolism

TREATMENT: ABC's  
Observe for other problems  
Administer oxygen  
Treat for shock  
Seek medical advice from hyperbaric physician

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## SUBCUTANEOUS EMPHYSEMA

Air trapped under skin around neck.

CAUSES: Same as Gas embolism

SYMPTOMS: Feeling of fullness around neck  
Change in voice  
Swelling in neck  
Crackling sound when skin is pressed

PREVENTION: Same as Gas embolism

TREATMENT: ABC's

Observe for other problems

Administer oxygen

Treat for shock

Seek medical advice from hyperbaric physician

**Note:** If any doubt about injury being more complicated than just Subcutaneous Emphysema, treat as Gas embolism.

**STINGING INJURIES**

CAUSES: Sponges, Corals, Jellyfish, Man-O-War, Fire Worm

SYMPTOMS: Itching, Burning

Redness and swelling, welts, (such as with poison ivy)

PREVENTION: Avoid marine organisms with stinging potential

TREATMENT: Check ABC's, Remove tentacles with saline rinse or remove carefully with forceps

Use hot water, vinegar or diluted ammonia to deactivate remaining nemomatcysts.

For more specific information contact the UM/RSMAS DSO

For severe injuries the victim should seek medical advice

**IMMEDIATE CARE OF DIVING ACCIDENT VICTIM**

Diver's Alert Network (DAN).....(919) 684-8111

1. CPR, if required.
  2. Keep victim in **supine position**.
  3. Maintain open **airway** and prevent aspiration of vomitus.
  4. Administer **100% oxygen** by Elder valve or Scot mask.
  5. Continue oxygen for 6 hours. Discontinue if necessary to reopen the airway or the victim shows signs of oxygen convulsions.
  6. **Protect victim** from heat or cold.
  7. **Contact a physician** experienced in diving medicine; DAN Phone # above.
  8. Give **fluids** (water) to conscious alert victim.
  9. If qualified medical personnel are present: IV fluid replacement with electrolyte solutions is preferred for unconscious or seriously injured victims. Ringer's lactate, normal saline, 5% dextrose in saline may be used, but 5% dextrose in water should not be used.
  10. If recompression treatment is required, contact chamber facility before sending victim; DAN Phone # above.
  11. If air evacuation is used, flight crews should be instructed to maintain cabin pressure as close to sea level as possible.
  12. Send victim's medical history with victim.
  13. If time/circumstances permit, conduct an initial neurological examination.
- 

#### **BASIC STEPS OF CPR**

1. **Open victim's airway** with head-tilt, chin-lift method.
2. If no breathing is detected, **give 2 breaths**. Watch for chest to rise.
6. Give 30 compression's to 2 breaths. **30:2 ratio for 5 cycles**.
7. Do CPR for approximately 2 minutes, then check for breathing.
8. If no breathing, continue CPR. Check for signs of life every 2 minutes.

## **APPENDIX 3**

### **AAUS STATISTICS COLLECTION CRITERIA AND DEFINITIONS**

#### **COLLECTION CRITERIA:**

The “Dive Time in Minutes”, The “Number of Dives Logged”, and the “Number of Divers Logging Dives” will be collected for the following categories:

- Dive Classification
- Breathing Gas
- Diving Mode
- Decompression Planning and Calculation Method
- Depth Ranges
- Specialized Environments
- Incident Types

Dive Time in Minutes is defined as the surface to surface time including any safety or required decompression stops.

A Dive is defined as a descent into water, an underwater diving activity utilizing compressed gas, an ascent/return to the surface, and a surface interval of greater than 10 minutes.

Dives will not be differentiated as openwater or confined water dives. But openwater and confined water dives will be logged and submitted for AAUS statistics classified as either scientific or training/proficiency.

A “Diver Logging a Dive” is defined as a person who is diving under the auspices of your scientific diving organization. Dives logged by divers from another AAUS Organization will be reported with the divers home organization. Only a diver who has actually logged a dive during the reporting period is counted under this category.

Incident(s) occurring during the collection cycle. Only incidents occurring during, or resulting from, a dive where the diver is breathing a compressed gas will be submitted to AAUS.

#### **DEFINITIONS:**

##### Dive Classification:

- Scientific Dives: Dives that meet the scientific diving exemption as defined in 29 CFR 1910.402.
- Diving tasks traditionally associated with a specific scientific discipline are considered a scientific dive. Construction and trouble-shooting tasks traditionally associated with commercial diving are not considered a scientific dive.
- Training and Proficiency Dives: Dives performed as part of a scientific diver training program, or
- dives performed in maintenance of a scientific diving Authorization/authorization.

##### Breathing Gas:

- Air: Dives where the bottom gas used for the dive is air.
- Nitrox: Dives where the bottom gas used for the dive is a combination of Nitrogen and Oxygen other than air.
- Mixed Gas: Dives where the bottom gas used for the dive is a combination of Oxygen, Nitrogen, and Helium (or other “exotic” gas), or any other breathing gas combination not classified as air or

### Diving Mode:

- Open Circuit SCUBA: Dives where the breathing gas is inhaled from a self contained underwater breathing apparatus and all of the exhaled gas leaves the breathing loop.
- Surface Supplied: Dives where the breathing gas is supplied from the surface by means of a pressurized umbilical hose. The umbilical generally consists of a gas supply hose, strength member, pneumofathometer hose, and communication line. The umbilical supplies a helmet or full-face mask. The diver may rely on the tender at the surface to keep up with the divers' depth, time and diving profile.
- Hookah: While similar to Surface Supplied in that the breathing gas is supplied from the surface by means of a pressurized hose, the supply hose does not require a strength member, pneumofathometer hose, or communication line. Hookah equipment may be as simple as a long hose attached to a standard SCUBA cylinder supplying a standard SCUBA second stage. The diver is responsible for the monitoring his/her own depth, time, and diving profile.
- Rebreathers: Dives where the breathing gas is repeatedly recycled in the breathing loop. The breathing loop may be fully closed or semi-closed. Note: A rebreather dive ending in an open circuit bailout is still logged as a rebreather dive.

### Decompression Planning and Calculation Method:

- Dive Tables
- Dive Computer
- PC Based Decompression Software

### Depth Ranges:

Depth ranges for sorting logged dives are 0-30, 31-60, 61-100, 101-130, 131-150, 151-190, and 191->. Depths are in feet seawater. A dive is logged to the maximum depth reached during the dive. Note: Only "The Number of Dives Logged" and "The Number of Divers Logging Dives" will be collected for this category.

### Specialized Environments:

- Required Decompression: Any dive where the diver exceeds the no-decompression limit of the decompression planning method being employed.
- Overhead Environments: Any dive where the diver does not have direct access to the surface due to a physical obstruction.
- Blue Water Diving: Openwater diving where the bottom is generally greater than 200 feet deep and requiring the use of multiple-tethered diving techniques.
- Ice and Polar Diving: Any dive conducted under ice or in polar conditions. Note: An Ice Dive would also be classified as an Overhead Environment dive.
- Saturation Diving: Excursion dives conducted as part of a saturation mission are to be logged by "classification", "mode", "gas", etc. The "surface" for these excursions is defined as leaving and surfacing within the Habitat. Time spent within the Habitat or chamber shall not be logged by AAUS.
- Aquarium: An aquarium is a shallow, confined body of water, which is operated by or under the control of an institution and is used for the purposes of specimen exhibit, education, husbandry, or research. (Not a swimming pool)

### Incident Types:

- Hyperbaric: Decompression Sickness, AGE, or other barotrauma requiring recompression therapy.
- Barotrauma: Barotrauma requiring medical attention from a physician or medical facility, but not requiring recompression therapy.
- Injury: Any non-barotrauma injury occurring during a dive that requires medical attention from a physician or medical facility.
- Illness: Any illness requiring medical attention that can be attributed to diving.
- Near Drowning/ Hypoxia: An incident where a person asphyxiates to the minimum point of unconsciousness during a dive involving a compressed gas. But the person recovers.
- Hyperoxic/Oxygen Toxicity: An incident that can be attributed to the diver being exposed to too high a partial pressure of Oxygen.
- Hypercapnea: An incident that can be attributed to the diver being exposed to an excess of carbon dioxide.
- Fatality: Any death accruing during a dive or resulting from the diving exposure.
- Other: An incident that does not fit one of the listed incident types

### Incident Classification Rating Scale:

- Minor: Injuries that the OM considers being minor in nature. Examples of this classification of incident would include, but not be limited to:
  - Mask squeeze that produced discoloration of the eyes.
  - Lacerations requiring medical attention but not involving moderate or severe bleeding.
  - Other injuries that would not be expected to produce long term adverse effects on the diver's health or diving status.
- Moderate: Injuries that the OM considers being moderate in nature. Examples of this classification would include, but not be limited to:
  - DCS symptoms that resolved with the administration of Oxygen, hyperbaric treatment given as a precaution.
  - DCS symptoms resolved with the first hyperbaric treatment.
  - Broken bones.
  - Torn ligaments or cartilage.
  - Concussion.
  - Ear barotrauma requiring surgical repair.
- Serious: Injuries that the OM considers being serious in nature. Examples of this classification would include, but not be limited to:
  - Arterial Gas Embolism.
  - DCS symptoms requiring multiple hyperbaric treatment.
  - Near drowning.
  - Oxygen Toxicity.
  - Hypercapnea.
  - Spinal injuries.
  - Heart attack.
  - Fatality.

## **APPENDIX 4 FORMS**

- a) Diving Resume
- b) Statement of Understanding
- c) Diving Medical Examination Forms
- d) Diving Medical History Forms
- e) Letter of Reciprocity

**UNIVERSITY OF MIAMI/RSMAS SCIENTIFIC DIVING PROGRAM  
DIVING RESUME**

Name:	Date:
Department:	Date of Birth:
Cell Phone:	Alternate Phone:
Address:	Social Security #:

Email Address \_\_\_\_\_

Emergency Contact (give Name, Relationship, Address, and day/evening phone numbers)

**TRAINING:** Please list all relevant training:

- |    |    |
|----|----|
| 1. | 4. |
| 2. | 5. |
| 3. | 6. |

**DIVING EXPERIENCE**

Total career open water scuba dives: \_\_\_\_\_ Total dives in last 12 months: \_\_\_\_\_

Deepest dive in career (depth/location): \_\_\_\_\_

Deepest dive in last year (depth/location): \_\_\_\_\_ Date of last dive: \_\_\_\_\_

**SNORKELING/SWIMMING EXPERIENCE:**

[ ] Non-swimmer      [ ] Swimmer      [ ] Snorkeler      [ ] Lifesaving      [ ] WSI

**DIVE LOG**

Please submit a photo-copy from your dive log book of either the last 12 months or last 12 dives, whichever is least.

Indicate with the appropriate letter, your diving experience in the following environments/conditions:

**E** = extensive (75+ )      **M** = moderate (25 - 74)      **L** = limited (1 - 24)      **O** = no experience

- |                   |                             |                      |
|-------------------|-----------------------------|----------------------|
| _____ small boats | _____ decompression diving  | _____ blue-water     |
| _____ ships       | _____ cold water (< 45 deg) | _____ turbid water   |
| _____ shore       | _____ ice diving            | _____ wreck          |
| _____ heavy surf  | _____ cave diving           | _____ kelp           |
| _____ mud/silt    | _____ fresh water lakes     | _____ night          |
| _____ dry suit    | _____ strong currents       | _____ surface supply |
| _____ saturation  | _____ chamber operation     | _____ coral reef     |
| _____ altitude    | _____ EMT/DMT               | _____ Nitrox/trimix  |
| _____ commercial  | _____ military              | _____ ocean/salt     |

STATEMENT: I certify that the above information is correct and accurate.

(Print Name)

(Signature)

(Date)



## STATEMENT OF UNDERSTANDING

Name: \_\_\_\_\_

Standard: All areas of evaluation of this course are based on the question: "Will this person make a safe and reliable diver?"

Evaluation: You will be required to learn and demonstrate to the satisfaction of the diving safety officer, through written examination and physical performance, the following:

1. Applied Sciences: Physics, physiology, and medical aspects of diving.
2. Diving Equipment: Knowledge of purposes, features, types and use of skin and scuba diving gear.
3. Diving Safety: Basic skill level of lifesaving, first aid, CPR and Diving Accident Management.
4. Diving Environment: Basic knowledge of physical and biological aspects, with emphasis on southeast Florida.
5. Safe Diving Skills: Competent knowledge and performance of skin and scuba diving, surface and underwater.

Authorization: You are not assured of authorization to dive for UM/RSMAS merely by attending the course, or even by completing and passing all of the areas of evaluation. The Diving Safety Officer will make a subjective decision at the end of the course, based on your total performance and attitude regarding safety. Possible initial authorizations are:

1. Diver-In-Training: Limited to a max depth of 30 feet and/or other restrictions as determined by the dive officer.
2. Scientific Diver Intermediate: Authorized to dive up to 30ft and allowed to dive to 60ft maximum with a diver authorized to a depth of 60ft or more. Cannot lead dives until more diving experience is achieved.
3. Scientific Diver 30ft: Authorized to dive up to 30ft as Lead Diver and allowed to dive to 60ft maximum with a diver authorized to a depth of 60ft or more.
4. Scientific Diver 60ft: Authorized to dive up to 60ft as Lead Diver and allowed to dive to 100ft maximum with a diver authorized to a depth of 100ft or more.
5. Requires additional training, as determined by the dive officer.
6. Rejection for diving authorization.

Responsibilities: You are responsible for the following:

1. Your own safety and others around you.
2. UM/RSMAS equipment – it is your responsibility to replace anything lost or damaged.
3. Your own gear and personal effects.
4. Be on time for all training sessions.
5. Pay fees on a timely basis.

Grading: Your final grade will be based on written exams, pool performance, open water performance, and your attitude toward safe diving practices.

---

(Candidate Signature)

(Date)

## STATEMENT OF UNDERSTANDING (cont.)

Name: \_\_\_\_\_

1. Skin, scuba, and surface-supplied diving are physical activities involving heavy exertion. A diver must be in good general health, free from cardiovascular and respiratory disease, and have good exercise tolerance. Even momentary loss of consciousness underwater may be fatal.
2. While swimming or using skin, scuba, or surface-supplied diving equipment, the body is subject to a variety of influences that may become potentially hazardous. Some of these hazards include drowning, ruptured ear drums or sinuses, air/gas embolism, decompression sickness, and a variety of other barotrauma (pressure-related injuries).
3. There are organisms in the water that may bite, sting, claw, or inject substances in the body.
4. There are other water related problems that include reduced visibility, rough water, strong currents, and cold temperature.
5. When diving from a boat a person may be subjected to bodily injury from carelessness due to activity, or related to equipment handling, or just from being present on a boat at sea.
6. The individual diver must realize that he/she is ultimately responsible for his/her own safety. It is clearly the diver's responsibility to refuse to dive if, in his/her judgment, conditions are unsafe.
7. The diver agrees to abide by all safety guidelines and policies learned in the RSMAS dive course.

Statement: I am in good physical and mental health and free from cardiovascular, respiratory, or other diseases or ailments, which could endanger me while diving. I hereby voluntarily exempt and release Rick Riera-Gomez, Robbie Christian, and the University of Miami, its Trustees, officers, and employees from liability for personal injury, property damage, or death arising from diving instruction, diving activities or any activities incidental to diving operations.

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(Candidate Signature)

(Date)

**UNIVERSITY OF MIAMI**  
**DIVING MEDICAL EXAM OVERVIEW FOR THE EXAMINING PHYSICIAN**

TO THE EXAMINING PHYSICIAN:

This person, \_\_\_\_\_, requires a medical examination to assess their fitness for

Authorization as a Scientific Diver for the University of Miami. Their answers on the Diving Medical History Form (attached) may indicate potential health or safety risks as noted. Your evaluation is requested on the attached SCUBA Diving Fitness Medical Evaluation Report. If you have questions about diving medicine, you may wish to contact physicians with expertise in diving medicine. Please contact the UM Diving Safety Officer if you have any questions or concerns about diving medicine or the University of Miami standards. Thank you for your assistance.

Rick Riera-Gomez      University of Miami      305.421.4107      rgomez@rsmas.miami.edu

SCUBA and other modes of compressed-gas diving can be strenuous and hazardous. A special risk is present if the middle ear, sinuses, or lung segments do not readily equalize air pressure changes. The most common cause of distress is eustachian insufficiency. Most fatalities involve deficiencies in prudence, judgment, emotional stability, or physical fitness. Please consult the following list of conditions that usually restrict candidates from diving.

(Adapted from Bove, 1998: bracketed numbers are pages in Bove)

**CONDITIONS WHICH MAY DISQUALIFY CANDIDATES FROM DIVING**

1. Abnormalities of the tympanic membrane, such as perforation, presence of a monomeric membrane, or inability to autoinflate the middle ears. [5 ,7, 8, 9]
2. Vertigo including Meniere's Disease. [13]
3. Stapedectomy or middle ear reconstructive surgery. [11]
4. Recent ocular surgery. [15, 18, 19]
5. Psychiatric disorders including claustrophobia, suicidal ideation, psychosis, anxiety states, untreated depression. [20 - 23]
6. Substance abuse, including alcohol. [24 - 25]
7. Episodic loss of consciousness. [1, 26, 27]
8. History of seizure. [27, 28]
9. History of stroke or a fixed neurological deficit. [29, 30]
10. Recurring neurologic disorders, including transient ischemic attacks. [29, 30]
11. History of intracranial aneurysm, other vascular malformation or intracranial hemorrhage. [31]
12. History of neurological decompression illness with residual deficit. [29, 30]
13. Head injury with sequelae. [26, 27]
14. Hematologic disorders including coagulopathies. [41, 42]
15. Evidence of coronary artery disease or high risk for coronary artery disease<sup>3</sup>. [33 - 35]
16. Atrial septal defects. [39]
17. Significant valvular heart disease - isolated mitral valve prolapse is not disqualifying. [38]
18. Significant cardiac rhythm or conduction abnormalities. [36 - 37]
19. Implanted cardiac pacemakers and cardiac defibrillators (ICD). [39, 40]
20. Inadequate exercise tolerance. [34]
21. Severe hypertension. [35]
22. History of spontaneous or traumatic pneumothorax. [45]

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<sup>3</sup> "Assessment of Cardiovascular Risk by Use of Multiple-Risk-Factor Assessment Equations." Grundy et. al. 1999. AHA/ACC Scientific Statement. <http://www.acc.org/clinical/consensus/risk/risk1999.pdf>

23. Asthma<sup>4</sup>. [42 - 44]
24. Chronic pulmonary disease, including radiographic evidence of pulmonary blebs, bullae, or cysts. [45,46]
25. Diabetes mellitus. [46 - 47]
26. Pregnancy. [56]

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### SELECTED REFERENCES IN DIVING MEDICINE

Most of these are available from Best Publishing Company, P.O. Box 30100, Flagstaff, AZ 86003-0100, the Divers Alert Network (DAN) or the Undersea and Hyperbaric Medical Association (UHMS), Bethesda, MD.

- “ACC/AHA Guidelines for Exercise Testing.” A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). Gibbons RJ, et al. 1997. Journal of the American College of Cardiology. 30:260-311. <http://circ.ahajournals.org/cgi/content/full/96/1/345>
- Alert Diver Magazine; Articles on diving medicine <http://www.diversalertnetwork.org/medical/articles/index.asp>
- “Are Asthmatics Fit to Dive?” Elliott DH, ed. 1996 Undersea and Hyperbaric Medical Society, Kensington, MD.
- “Assessment of Cardiovascular Risk by Use of Multiple-Risk-Factor Assessment Equations.” Grundy et. al. 1999. AHA/ACC Scientific Statement. <http://circ.ahajournals.org/cgi/reprint/circulationaha;100/13/1481>
- DIVING MEDICINE, Third Edition, 1997. A. Bove and J. Davis. W.B. Saunders Company, Philadelphia
- DIVING AND SUBAQUATIC MEDICINE, Third Edition, 1994. C. Edmonds, C. Lowery and J. Pennefather. Butterworth-Heinemann Ltd. Oxford
- MEDICAL EXAMINATION OF SPORT SCUBA DIVERS, 1998. Alfred Bove, M.D., Ph.D. (ed.). Medical Seminars, Inc. San Antonio, TX
- NOAA DIVING MANUAL, NOAA. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.
- U.S. NAVY DIVING MANUAL. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

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<sup>4</sup> “Are Asthmatics Fit to Dive?” Elliott DH, ed. 1996 Undersea and Hyperbaric Medical Society, Kensington, MD.

**UNIVERSITY OF MIAMI  
MEDICAL EVALUATION OF FITNESS FOR SCUBA DIVING REPORT**

\_\_\_\_\_  
Name of Applicant (Print or Type)

\_\_\_\_\_  
Date (Mo/Day/Year)

To The PHYSICIAN:

This person is an applicant for training or is presently certified to engage in diving with self-contained underwater breathing apparatus (SCUBA). This is an activity that puts unusual stress on the individual in several ways. Your opinion on the applicant's medical fitness is requested. SCUBA diving requires heavy exertion. The diver must be free of cardiovascular and respiratory disease. An absolute requirement is the ability of the lungs, middle ear and sinuses to equalize pressure. Any condition that risks the loss of consciousness should disqualify the applicant.

**TESTS:** Please initial that the following tests were completed.

**[ ] Initial Examination**

- \_\_\_\_\_ Medical History
- \_\_\_\_\_ Complete Physical Exam with emphasis on neurological and otological components
- \_\_\_\_\_ Chest X-Ray
- \_\_\_\_\_ Spirometry
- \_\_\_\_\_ Hematocrit or Hemoglobin
- \_\_\_\_\_ Urinalysis
- \_\_\_\_\_ Any further tests deemed necessary by the physician

**[ ] Re-examination**

**(Every 5 years under age 40,  
first exam over age 40,  
every 3 years over age 40,  
every 2 years over age 60)**

- \_\_\_\_\_ Medical History
- \_\_\_\_\_ Complete Physical Exam, with emphasis on neurological and otological components
- \_\_\_\_\_ Hematocrit or Hemoglobin
- \_\_\_\_\_ Urinalysis
- \_\_\_\_\_ Any further tests deemed necessary by the physician

**Additional testing for first over age 40**

- \_\_\_\_\_ Resting EKG
- \_\_\_\_\_ Assessment of coronary artery disease using Multiple-Risk-Factor Assessment<sup>5</sup>  
(age, lipid profile, blood pressure, diabetic screening, smoker) Note: Exercise stress testing may be indicated based on risk factor assessment<sup>6</sup>

**Additional testing for over age 40**

- \_\_\_\_\_ Resting EKG
- \_\_\_\_\_ Assessment of coronary artery disease using Multiple-Risk-Factor Assessment<sup>5</sup>  
(age, lipid profile, blood pressure, diabetic screening, smoker) Note: Exercise stress testing may be indicated based on risk factor assessment<sup>6</sup>

**RECOMMENDATION:**

- [ ] APPROVAL. I find no medical condition(s) that I consider incompatible with diving.
- [ ] RESTRICTED ACTIVITY APPROVAL. The applicant may dive in certain circumstances as described in REMARKS. [ ] REJECT. This applicant has medical condition(s), which, in my opinion, clearly would constitute unacceptable hazards to health and safety in diving

<sup>5</sup> "Assessment of Cardiovascular Risk by Use of Multiple-Risk-Factor Assessment Equations." Grundy et. al. 1999. AHA/ACC Scientific Statement. <http://www.acc.org/clinical/consensus/risk/risk1999.pdf>

<sup>6</sup> Gibbons RJ, et al. ACC/AHA Guidelines for Exercise Testing. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). Journal of the American College of Cardiology. 30:260-311, 1997. <http://www.acc.org/clinical/guidelines/exercise/exercise.pdf>  
Revised 1/14

**REMARKS:**

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**PHYSICIAN'S STATEMENT:**

I have evaluated the above-mentioned individual according to the American Academy of Underwater Sciences medical standards for scientific diving (Section 6.00), and find no conditions that may be disqualifying. I have discussed with the patient any medical condition(s) that would not disqualify him/her from diving but which may seriously compromise subsequent health. The patient understands the nature of the hazards and the risks involved in diving with these conditions.

\_\_\_\_\_ MD or DO  
Date    Signature

Name (Print or Type)	Address	Telephone Number
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My familiarity with applicant is:

With this exam only  
 Regular Physician for \_\_\_\_\_ years  
 Other (describe) \_\_\_\_\_

My familiarity with diving medicine is:

**APPLICANT'S RELEASE OF MEDICAL INFORMATION FORM**

I authorize the release of this information and all medical information subsequently acquired in association with my diving to the \_\_\_\_\_ Diving Safety Officer and Diving Control Board or their designee at (place) \_\_\_\_\_ on

(date)\_\_\_\_\_.  
Signature of Applicant \_\_\_\_\_

**UNIVERSITY OF MIAMI DIVING  
MEDICAL HISTORY FORM**

(To Be Completed By Applicant-Diver)

Name \_\_\_\_\_ Sex \_\_\_\_ Age \_\_\_\_ Wt. \_\_\_\_ Ht. \_\_\_\_

Sponsor \_\_\_\_\_

Date \_\_\_\_ / \_\_\_\_ / \_\_\_\_

\_\_\_\_\_  
(Dept./Project/Program/School, etc.)

\_\_\_\_\_  
(Mo/Day/Yr)

**TO THE APPLICANT:**

SCUBA diving makes considerable demands on you, both physically and mentally. Diving with certain medical conditions may be asking for trouble not only for yourself, but also to anyone coming to your aid if you get into difficulty in the water. Therefore, it is prudent to meet certain medical and physical requirements before beginning a diving or training program.

Your answers to the questions are as important, in determining your fitness as your physical examination. Obviously, you should give accurate information or the medical screening procedure becomes useless.

This form shall be kept confidential. If you believe any question amounts to invasion of your privacy, you may elect to omit an answer, provided that you shall subsequently discuss that matter with your own physician and they must then indicate, in writing, that you have done so and that no health hazard exists.

Should your answers indicate a condition, which might make diving hazardous, you will be asked to review the matter with your physician. In such instances, their written authorization will be required in order for further consideration to be given to your application. If your physician concludes that diving would involve undue risk for you, remember that they are concerned only with your well-being and safety. Please respect the advice and the intent of this medical history form.

	<b>Have you ever had or do you presently have any of the following?</b>	<b>Yes</b>	<b>No</b>	<b>Comments</b>
1.	Trouble with your ears, including ruptured eardrum, difficulty clearing your ears, or surgery.			
2.	Trouble with dizziness.			
3.	Eye surgery.			
4.	Depression, anxiety, claustrophobia, etc.			
5.	Substance abuse, including alcohol.			
6.	Loss of consciousness.			
7.	Epilepsy or other seizures, convulsions, or fits.			
8.	Stroke or a fixed neurological deficit.			
9.	Recurring neurologic disorders, including transient ischemic attacks.			
10.	Aneurysms or bleeding in the brain.			
11.	Decompression sickness or embolism.			
12.	Head injury.			
13.	Disorders of the blood, or easy bleeding.			
14.	Heart disease, diabetes, high cholesterol.			
15.	Anatomical heart abnormalities including patent foramen ovale, valve problems, etc.			
16.	Heart rhythm problems.			
17.	Need for a pacemaker.			
18.	Difficulty with exercise.			
19.	High blood pressure.			

20.	Collapsed lung.			
21.	Asthma.			
22.	Other lung disease.			
23.	Diabetes mellitus.			
24.	Pregnancy.			
25.	Surgery If yes explain below.			
26.	Hospitalizations. If yes explain below.			
27.	Do you take any medications? If yes list below.			
28.	Do you have any allergies to medications, foods, and environmental? If yes explain below.			
29.	Do you smoke?			
30.	Do you drink alcoholic beverages?			
31.	Is there a family history of high cholesterol?			
32.	Is there a family history of heart disease or stroke?			
33.	Is there a family history of diabetes?			
34.	Is there a family history of asthma?			

Please explain any “yes” answers to the above questions.

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I certify that the above answers and information represent an accurate and complete description of my medical history.

Signature \_\_\_\_\_

Date\_\_\_\_\_



**UNIVERSITY OF MIAMI  
REQUEST FOR DIVING RECIPROCITY FORM  
VERIFICATION OF DIVER TRAINING AND EXPERIENCE**

Diver: \_\_\_\_\_

Date: \_\_\_\_\_

This letter serves to verify that the person listed above has met the training and pre-requisites as indicated below, and has completed all requirements necessary to be authorized as a *(Scientific Diver / Diver in Training)* as established by the University of Miami Diving Safety Manual, and has demonstrated competency in the indicated areas. The University of Miami is an AAUS OM and meets or exceeds all AAUS training requirements.

**The following is a brief summary of this diver's personnel file regarding dive status at**

(Date)

\_\_\_\_\_ Original diving authorization  
 \_\_\_\_\_ Written scientific diving examination  
 \_\_\_\_\_ Last diving medical examination      Medical examination expiration date \_\_\_\_\_  
 \_\_\_\_\_ Most recent checkout dive  
 \_\_\_\_\_ SCUBA regulator/equipment service/test  
 \_\_\_\_\_ CPR training (Agency) \_\_\_\_\_      CPR Exp. \_\_\_\_\_  
 \_\_\_\_\_ Oxygen administration (Agency) \_\_\_\_\_      O2 Exp. \_\_\_\_\_  
 \_\_\_\_\_ First aid for diving \_\_\_\_\_      F.A. Exp. \_\_\_\_\_

\_\_\_\_\_ Date of last dive      \_\_\_\_\_ Depth

Number of dives completed within previous 12 months? \_\_\_\_\_      Depth Authorization \_\_\_\_\_ fsw  
 Total number of career dives? \_\_\_\_\_

Any restrictions? (Y/N) \_\_\_\_\_ if yes, explain:

Please indicate any pertinent specialty Authorizations or training:

Emergency Information:

Name: \_\_\_\_\_ Relationship: \_\_\_\_\_  
 Telephone: \_\_\_\_\_ (work) \_\_\_\_\_ (home)  
 Address: \_\_\_\_\_

This is to verify that the above individual is currently an authorized scientific diver at \_\_\_\_\_

Diving Safety Officer:

\_\_\_\_\_  
 (Signature)

\_\_\_\_\_  
 (Date)

\_\_\_\_\_  
 (Print Name)